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Cover Photograph: Ruby-throated Hummingbird (*Archilochus colubris)*

Cover Photograph: Photo is courtesy of Bill Garland, U.S. Fish and Wildlife Service, Biologist, Anniston, Alabama. Photo was taken at Mountain Longleaf National Wildlife Refuge, Alabama.

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DISTRIBUTION OF THE ASIAN COCKROACH, *Blattella asahinai* (DICTYOPTERA: BLATTELLIDAE), IN DOTHAN, ALABAMA

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ABSTRACT

The city-wide distribution of the Asian cockroach, *Blattella asahinai* Mizukubo, was determined in Dothan, Alabama in 2008. Surveys were conducted in the summers of 2004 and 2008 and consisted of site visits to all city parks and municipal facilities as well as a number of home, business, and municipal landscapes. Asian cockroaches were found at 95.1% of the locations we examined in 2008. Several sites were sampled at most locations for a total of 65 sites. The elevation of sites with Asian cockroaches was 114.00 ± 5.76 m (mean ± SD) above sea level. Of the 63 sites with Asian cockroaches, the cockroaches were found in pine straw at 36 (57.1%) sites and in oak leaf litter at 23 (36.5%) sites. Based on this survey, we conclude that the Asian cockroach is distributed throughout the city of Dothan.

INTRODUCTION

Following several reports of "flying" German cockroaches, *Blattella germanica* (L.), in the fall of 2003 from Alabama Cooperative Extension System agents in southeastern Alabama, specimens were obtained for identification. Using adult male specimens and characters and keys described by Mizukubo (1981) and Roth (1985, 1986), the specimens were confirmed as the Asian cockroach, *Blattella asahinai* Mizukubo. The Asian cockroach was first recorded in the United States from specimens collected in Lakeland, Florida in 1986 (Brenner et al., 1986; Roth, 1986; Koehler and Patterson, 1987). Subsequently the distribution of this species has increased dramatically, and it is now established in all Florida counties (Richman, 2005; Donahoe, 2005; P. G. Koehler, pers. com.). Additional reports of Asian cockroach infestations have included eight counties in Alabama and seven counties in Georgia (Grush, 2003; Snoddy and Appel, 2008a), Charleston and Kiawah Island, South

Carolina (Sitthicharoenchai, 2002; Hu et al., 2005), and Houston and Weslaco, Texas (Tucker, 2006; Austin et al., 2007; Pfannenstiel et al., 2008).

The Asian cockroach is very similar in appearance to the German cockroach and a number of other *Blattella* species (Roth, 1985). Unlike the German cockroach, the Asian cockroach is a peridomestic rather than a domestic pest (Brenner et al., 1988). Huge populations may develop in lawns, mulches, leaf litter, and other warm, humid, and dark substrates (Brenner et al., 1988; Snoddy et al., 2008). Although they do not generally establish populations indoors, Asian cockroaches often enter homes at night because they are attracted to lights, including televisions. Species identification is critical so that control measures are applied to the appropriate locations: indoors primarily in kitchens and bathrooms for German cockroaches and outdoors in heavily mulched areas for Asian cockroaches.

Since the Asian cockroach was first reported in Alabama from several homes in Dothan (Hu et al., 2005), our objective was to determine the distribution of this species within the city limits. Dothan is located in Houston County and is the only major city in southeastern Alabama. Several major highways including Interstate 10, and U.S. highways 82, 231, 331, and 431, connect Dothan with southwestern Georgia, northern Florida, and much of Alabama. These highways have been implicated in the increasing distribution of the Asian cockroach in Alabama and Georgia (Snoddy and Appel, 2008a, b).

MATERIALS AND METHODS

Survey Methods

Sites throughout the city of Dothan, Alabama were surveyed for the presence of Asian cockroaches using several methods. Heavily mulched areas and areas covered with leaf litter were visually inspected. Two to three square meter areas of mulch or leaf litter were probed with the handle of an insect net for no more than 5 min or until flying cockroaches were observed. We also examined outdoor trash receptacles, areas beneath landscape timbers, and around large objects such as fountains and playground equipment.

Cockroaches were collected with sweep nets, aspirators, or by hand. Specimens were sacrificed killed and stored in 70% ethanol and returned to the laboratory to confirm their identity. We relied on adult male characters as described by Mizukubo (1981) and Roth (1985, 1986) to confirm the identification of the Asian cockroach. Specifically, we examined the morphology of the tergal glands located on the 7th and 8th abdominal tergites and the subgenital plate. To examine these characters, slide mounts of the tergal glands and subgenital plate were prepared as described by Roth (1985). In addition, other adult morphological charaeters (Lawless, 1998) and the behavioral character of adult flight were consistent with the identification of *B. asahinai*. At least three adult male specimens from each site were prepared as above and identified from specimens collected in 2004.

Collections and Collection Sites

We sampled sites throughout Dothan, Alabama on several dates in June and July 2004 and intensively in August 2008. We sampled in late summer and early fall because

populations of the Asian cockroach reach peak abundance in southern Alabama at those seasons (Snoddy, 2007).

In 2004, we sampled several parks, municipal facilities, and landscapes surrounding single family homes whose residents had contacted the Alabama Cooperative Extension System. In 2008, using the same sampling methods, we intensively surveyed all parks, recreation areas and municipal facilities (including cemeteries, schools, and hospitals) throughout the city of Dothan (Fig. 1). In addition, we recorded the location (Waypoint) of each site in which Asian cockroaches were found using a Garmin model GPSmap 60CSx (Garmin International, Olathe, KS) GPS receiver. GPS coordinates were downloaded from the receiver and mapped using ESRI® ArcMap 9.2 software (ESRI Inc., Redlands, CA).

RESULTS

A total of seven parks and five residences were inspected in 2004, and all had large populations of Asian cockroaches. The cockroaches were always found in association with organic refuse: near and under park dumpsters and behind residential trash cans. The cockroaches were also present in leaf litter (holly, magnolia, oak, and pecan) and pine straw mulch. We also visited a number (15) of additional locations throughout Dothan, including parks and schools, and did not find Asian cockroaches. Therefore in 2004, Asian cockroaches were present in 44% of the locations sampled.

In 2008, we conducted a thorough systematic survey of Dothan for the Asian cockroach. A total of 41 locations were selected and sampled throughout the city. We detected Asian cockroaches at 39 of the 41 locations (95.1%). At most locations, several sites were sampled and geographic data for a total of 65 sites were recorded (Fig. 1, Table 1). The elevation of sites with Asian cockroaches ranged from 104.85 to 123.75 m with a mean of 114.00 ± 5.76 m (Table 1). Of the 63 sites with Asian cockroaches, the cockroaches were found in pine straw at 36 (57.1%) sites and in oak leaf litter at 23 (36.5%) sites (Table 1). At two sites (Waypoints 28 and 29), populations of Asian cockroaches were found in mixed oak leaf litter and pine straw together with trash such as paper cups, cardboard boxes, and aluminum soda cans all atop asphalt in a parking lot.

Table 1. Geographical location, elevation, and substrates on which *Blattella asahinai* populations were sampled in Dothan, AL in August 2008.

Waypoint number1	Position (WGS 84)	Elevation above sea level (m)	Site, type of stustrate
1	N31 18.314 W85 21.210	104.24	Park, pine bark mulch2
2	N31 17.767 W85 22.190	104.55	Park, pine bark mulch2
3	N31 17.344 W85 22.202	104.85	Park, in pine straw mulch
4	N31 17.369 W85 22.196	105.16	Park, in oak leaf litter
5	N31 16.053 W85 22.849	105.46	School, in oak leaf litter
6	N31 16.068 W85 22.840	105.77	School, in oak leaf litter
7	N31 16.026 W85 22.816	106.07	School, in oak leaf litter
8	N31 15.642 W85 22.362	106.38	Park, in oak leaf litter
9	N31 15.648 W85 22.366	106.68	Park, in oak leaf litter
10	N31 13.894 W85 25.855	106.98	Shopping center, in pine straw
11	N31 13.905 W85 25.846	107.29	Shopping center, in pine straw
12	N31 14.182 W85 25.457	107.59	Park, in mixed hardwood leaf litter
13	N31 14.192 W85 25.453	107.90	Park, in mixed hardwood leaf litter
14	N31 14.393 W85 25.280	108.20	School, in pine straw / holly leaf litter
15	N31 14.391 W85 25.290	108.51	School, in pine straw / rose leaf litter
16	N31 14.513 W85 25.288	108.81	School, in pine straw / pecan leaf litter
17	N31 14.526 W85 25.270	109.12	School, in pine straw
18	N31 14.514 W85 25.276	109.42	School, in pine straw
19	N31 15.171 W85 25.464	109.73	Shopping center, in pine straw
20	N31 15.158 W85 25.465	110.03	Shopping center, in pine straw
21	N31 16.301 W85 25.910	110.34	Rehabilitation center, in oak leaf litter
22	N31 16.311 W85 25.820	110.64	Rehabilitation center, in oak leaf litter
23	N31 14.364 W85 26.396	110.95	Recreation center, in magnolia leaf litter and pine straw
24	N31 14.266 W85 26.372	111.25	Recreation center, in pine straw
25	N31 14.327 W85 26.314	111.56	Recreation center, in pine straw
26	N31 14.625 W85 26.953	111.86	School, in pine straw
27	N31 13.597 W85 24.161	112.17	Shopping center, in oak leaf litter and pine straw on asphalt parking lot
28	N31 13.587 W85 24.162	112.47	Shopping center, in oak leaf litter and pine straw on asphalt parking lot
29	N31 13.554 W85 23.501	112.78	Civic center parking lot, in palm and oak leaf litter and pine straw
30	N31 13.475 W85 23.402	113.08	Civic center parking lot, in holly leaf litter

31	N31 13.483 W85 23.320	113.39	Museum, in weeds next to building
32	N31 13.323 W85 22.506	113.69	Cemetery, in pine, not juniper, straw
33	N31 12.838 W85 22.525	114.00	Park, in oak leaf litter
34	N31 12.709 W85 22.530	114.30	School, in pine straw
35	N31 13.036 W85 21.812	114.60	Medical center, in pine straw
36	N31 11.742 W85 22.336	114.91	Mental health center, in pine straw
37	N31 11.752 W85 22.352	115.21	Mental health center, in pine straw
38	N31 11.759 W85 22.358	115.52	Mental health center, in pine straw
39	N31 11.655 W85 22.457	115.82	Farm center, in pine straw
40	N31 11.372 W85 23.986	116.13	Shopping center, in pine straw
41	N31 12.424 W85 23.684	116.43	Park, in oak leaf litter
42	N31 12.423 W85 23.694	116.74	Park, in oak leaf litter
43	N31 12.481 W85 23.668	117.04	School, in pine straw
44	N31 12.469 W85 23.676	117.35	School, in pine straw
45	N31 12.319 W85 24.080	117.65	Stadium, in cherry and oak leaf litter
46	N31 12.570 W85 24.879	117.96	School, in azalea leaf litter
47	N31 12.328 W85 25.870	118.26	Cemetery, in pine straw
48	N31 12.307 W85 26.083	118.57	School, in holly leaf litter and pine straw
49	N31 12.286 W85 26.100	118.87	School, in pine straw
50	N31 11.384 W85 25.346	119.18	Cemetery, in oak leaf litter
51	N31 11.380 W85 25.321	119.48	Cemetery, in pine straw
52	N31 11.380 W85 25.309	119.79	Cemetery, in pine straw
53	N31 13.839 W85 24.291	120.09	School, in oak leaf litter
54	N31 13.851 W85 24.286	120.40	School, in dogwood leaf litter
55	N31 14.158 W85 24.110	120.70	School, in monkey grass litter
56	N31 14.262 W85 24.045	121.01	Cemetery, in oak leaf litter
57	N31 14.251 W85 24.020	121.31	Cemetery, in deciduous leaf litter
58	N31 14.138 W85 22.475	121.62	School, in pine straw
59	N31 14.027 W85 22.298	121.92	School, in oak leaf litter
60	N31 14.031 W85 22.315	122.22	School, in pine straw
61	N31 13.616 W85 21.542	122.53	Rehabilitation center, in pine straw
62	N31 13.611 W85 21.586	122.83	Rehabilitation center, in pine straw
63	N31 14.566 W85 23.316	123.14	School, in pine straw
64	N31 14.567 W85 23.341	123.44	School, in pine straw
65	N31 14.997 W85 23.294	123.75	Shopping center, in mixed organic debris

[1]Waypoint numbers correspond to the location number markers in Figure 1.
[2]No cockroaches were observed.

DISCUSSION

Present in several (44%) locations in 2004, the Asian cockroach is now distributed throughout Dothan, Alabama. Although we sampled only public areas such as parks and schools in 2008, given the wide area of distribution (Fig. 1), it is reasonable to assume that the city of Dothan is generally infested with the Asian cockroach. The two locations where we could not find Asian cockroaches were the northernmost surveyed. It is possible that we did not detect cockroaches that were present or that Asian cockroaches had not yet been transported to those loeations. Snoddy and Appel (2008a) found that the distribution of Asian cockroaches followed major highways and interstates northward from Florida into Alabama and Georgia and concluded that this species may be carried to new locations by human transportation. Similarly, Tucker (2006) and Austin et al. (2007) found Asian cockroaches in Houston, Texas adjacent to a major East-West interstate (I-10) and Pfannenstiel et al. (2008) reported this species from soybean fields approximately 394 km south of San Antonio, Texas and Interstate 10. Since there are no obvious geographic or macro-climatic differences between locations in Dothan, Alabama with and without Asian cockroaches, it is likely that either the cockroaches had not been transported to those locations, or that micro-climatic conditions (Snoddy, 2007) or resources were insufficient to support a population.

Asian cockroaches were found in leaf litter (primarily oak) or pine straw in all locations in Dothan where they were detected. Asian coekroaches have been associated with both living and dead plant material. They are most often associated with these materials when these materials are used as mulches or oecur as leaf litter. It is likely that these cockroaches harbor in covered areas beeause they are darker, provide higher levels of humidity, and potentially contain food. Even though adult Asian cockroaches will readily fly when disturbed during the day and are attraeted to bright lights at night, they are generally repelled by light during the day (Snoddy and Appel, personal observations). Loose pine straw mulch and leaf litter covering soil provide darkness and a large surface area for harborage. These materials also retain moisture, resulting in high humidity within the harborage. In laboratory experiments with other peridomestic cockroaches, Appel and Smith (1996) found that *Periplaneta* spp. preferred the most humid mulch material even though it did not have the smallest relative interstitial spaces or the lowest light intensity.

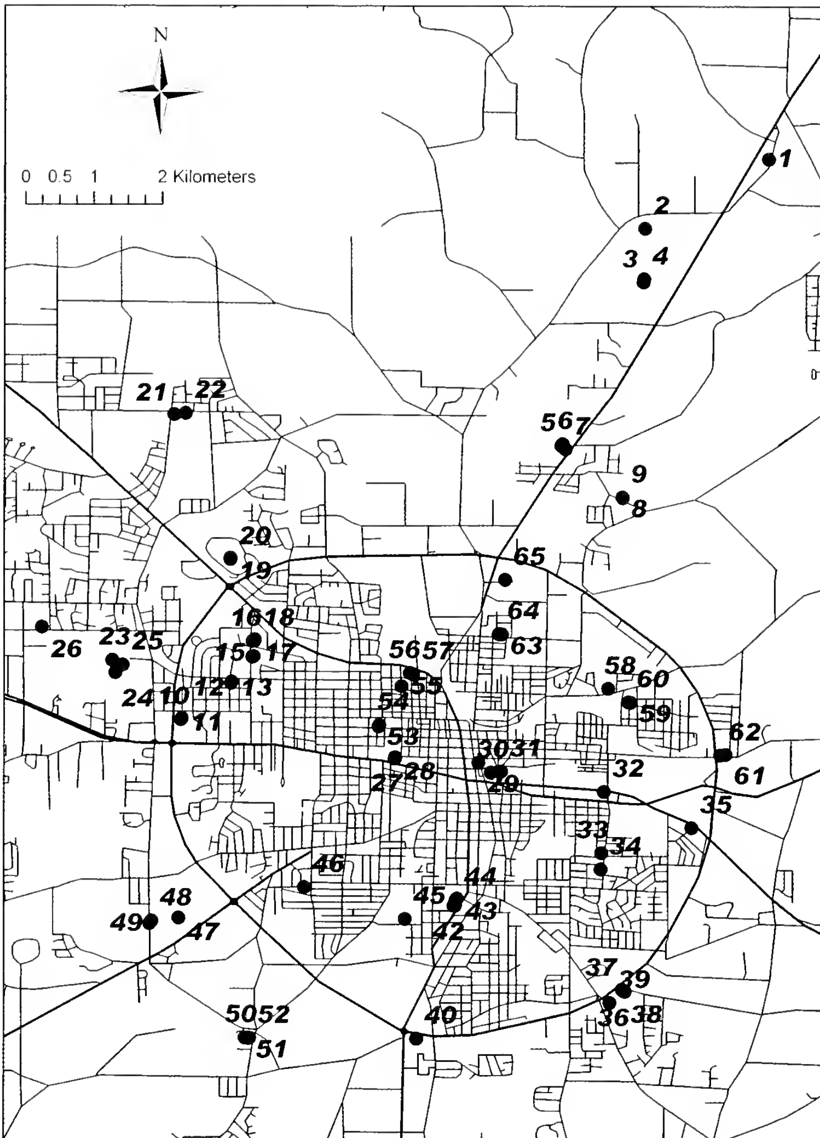

Figure 1. Distribution of the Asian cockroach, *Blattella asahinai*, in Dothan, Alabama. Numbered waypoints described in Table 1.

At several locations Asian cockroaches were found at one or more sites, but not at others, even 1-2 m nearby. We found that areas with tightly packed pine bark, red colored wood mulch, or juniper leaves did not support Asian cockroaches. It is possible that tightly packed moist mulch, particularly in direet sunlight, becomes too warm for cockroaches to inhabit. In the ease of juniper mulch, we not only observed tightly packed leaves, but large numbers of juniper cones (berries) and detected an obvious eedar odor to the mulch. Juniper flake board was significantly repellent to the closely related German cockroach in laboratory studies (Appel and Mack, 1989) and may also be repellent to Asian cockroaches.

Asian cockroaches are clearly present throughout the city of Dothan, Alabama (Fig. 1). They are associated with outdoor organic materials including mulches, leaf litter, and other debris. This species was likely transported into Dothan, possibly on cars and trucks carrying mulch and plant material from Florida (Smith, 2006). Since its introduction into Florida in 1985 (Roth, 1986), this invasive species has spread throughout Florida and into at least four additional states. Further research on the behavior, ecology, and physiology of this species will lead to the development of a comprehensive integrated pest management system for this rapidly spreading peridomestic pest.

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TEMPERATURE AND RAINFALL TRENDS IN SOUTH CENTRAL ALABAMA AND WESTERN GEORGIA, 1948-2006

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ABSTRACT

Temperature and rainfall data for the Montgomery region in south central Alabama and western Georgia was evaluated for the years 1948-2006. The data revealed a slight decrease in average annual temperature and an increase in average annual precipitation over this time period. Further analysis of the data found a significant decrease in average spring temperatures and a significant increase in average fall rainfall. In addition, summer and winter temperature data were found to have a reasonable degree of correlation with several annual and seasonal weather factors.

INTRODUCTION

Daily reports of global warming fill the airwaves. In 2007, the United Nations Intergovernmental Panel on Climate Change issues its fourth assessment indicating that major changes in global climate are being observed (UNIPCC, 2007). A former Vice-President wins both an Academy Award and a Nobel Prize for his work on climate change. In our classrooms, discussions of global warming are among the most popular topics in our introductory biology and environmental science classes. These discussions lead us to question what is happening locally. Can we detect climate change here? Is it getting warmer, wetter, cooler, or drier in our region?

Besides answering students' questions, there is a real value to learning about our local climate. Each year there are reports of major farm losses in the state due to the weather. A late spring frost wipes out the Chilton County peach crop, or a harsh summer drought ruins the peanut harvest in Dothan. While Alabama may not rank among the premier agricultural producing states nationally, no one can question agriculture's importance in the state's economy. According to the Farm Service Agency of the United States Department of Agriculture, Alabama's 45,000 farms produce at least 50 different commercial crops and

livestock and employ 21% of the state's workforce (FSA, 2008).

Numerous studies of local and regional climate data have been reported in the literature. For example, in preparing this work, we consulted a paper on climate fluctuations in the Czech Republic (Brazdil et al., 2008), a study on changes in temperature extremes in Italy (Toreti and Desiato, 2007) and a note on changes in temperature trends in the United States (Lu et al., 2005). Indeed, concern about changes in local climate is not a new phenomenon. In a classic study of temperature trends in Aberdeen, Scotland from 1870 to 1932, A. E. M. Geddes observed:

There appears to be a fairly persistent belief that our climate is changing, and the winters are not what they were in our fathers' and grandfathers' times as regard to severity, nor are the summers so bright and warm. (Geddes, 1935).

From our experience, this belief persists to the present day. As teachers of first-year mathematics and science students, we were impressed by the simple elegance of Geddes' study. The author uses a mathematically simple model that employs twenty-year moving averages to illustrate long-term trends in local temperature data. While not as sophisticated as many of the newer climatological models, Geddes' approach is readily understood and demonstrates clearly that changes in climate have occurred during the period under analysis. The objective of this paper is to employ a similar approach to describe temperature and precipitation trends as observed in the region surrounding Montgomery, Alabama during the period 1948-2006.

MATERIALS AND METHODS

Temperature and precipitation data were obtained from the National Climatic Data Center's website, ***http://www.ncdc.noaa.gov.*** Thirteen stations in the region surrounding Montgomery, Alabama were selected for this study: Andalusia, Alabama; Brewton, Alabama; Columbus, Georgia; Cuthbert, Georgia; Greensboro, Alabama; Highland Home, Alabama; Montgomery, Alabama; Selma, Alabama; Talladega, Alabama; Thomasville, Alabama; Troy, Alabama; Union Springs, Alabama; and West Point, Georgia. (See Fig. 1) Each city was selected on the basis of its proximity to Montgomery and the completeness of its temperature and precipitation data for the period. Efforts were made to select sites distributed in a reasonably uniform pattern in the region surrounding Montgomery.

It should be noted that each of the weather stations moved at some point during 1948-2006, some with multiple moves. Most of these changes were minor in nature, and they have been treated as insignificant for the purposes of this study. Some of this data may also reflect an urban heat island effect especially in the two metropolitan areas in the data sets, Columbus, Georgia and Montgomery, Alabama, which both grew significantly in the past 50 years. The impact of this effect should be fairly minimal as only two of the 12 sites are in urban areas, and in the case of Montgomery, most of the urban development has been away and eastward from the weather station.

The years studied are also a compromise to the data sets available. The years

1948-2006 were selected based on the ready availability of reliable and complete weather information for the region. All data sets employed in this study were at least 95% complete. Any missing data were replaced by averaging adjacent available data. As far as we know, there is nothing significant about using 1948 as the starting point for our study.

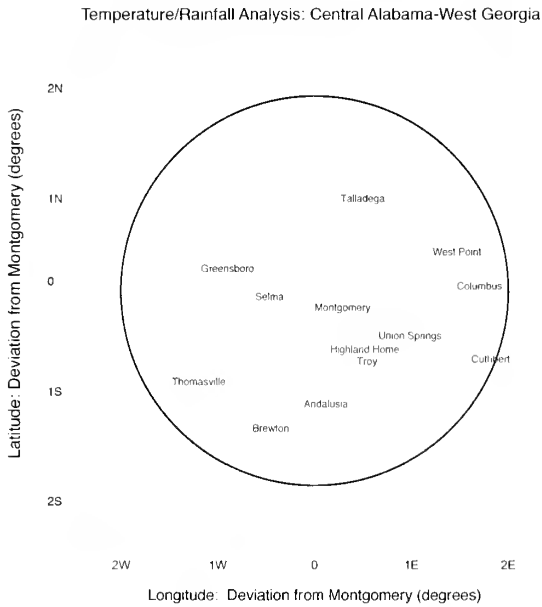

Figure 1: The thirteen locations studied and their geographic position relative to Montgomery, Alabama.

Information from each of the thirteen stations was averaged to create regional temperature and precipitation statistics. In addition, seasonal data sets were assembled for study: Winter (December-February), Spring (March-May), Summer (June-August), and Fall (September-November). In each case, we considered December to be the first month of the calendar year; e.g. in our study, the year 1948 runs from December 1947 through November 1948.

Following Geddes' example, we smoothed each data set using a 10-year simple moving average. To calculate the smoothed data Y_i^* corresponding to the year i, we employed the formula

$$Y_i^* = \sum_{j=(i-9)}^{i} Y_j ,$$

where Y_j is the raw data that corresponds to the year j. For example, unless otherwise noted, the smoothed information we report for the year 1957 is the average of the data associated with the years 1948-1957.

RESULTS

A summary of the region's raw, unsmoothed monthly weather information for the period 1948-2006 is shown in Table 1. Regional average annual temperatures are displayed in Figure 2

Table 1. Regional average temperature and precipitation, 1948-2006.

Month	Average temperature (C)	Maximum temperature (C)	Minimum temperature (C)	Average precipitation (cm)	Temperature variance (C)	Precipitation variance (cm)
December	9.28	14.30	4.89	12.16	4.00	28.85
January	8.33	16.85	2.41	12.21	7.26	21.13
February	10.20	15.22	5.16	12.76	4.71	29.69
March	13.82	17.20	9.10	15.63	2.94	42.16
April	18.00	21.23	15.35	11.51	2.06	34.75
May	22.20	24.93	19.34	10.21	1.43	22.33
June	25.63	28.31	23.79	11.40	0.88	26.43
July	27.08	28.66	25.33	14.35	0.60	27.10
August	26.76	29.15	25.14	10.43	0.72	12.88
September	24.13	26.55	21.21	10.30	1.18	29.34
October	18.51	21.95	15.24	7.08	2.21	27.02
November	13.17	17.17	9.34	10.36	2.69	37.81

Temperature:

We began our analysis with a review of the region's unsmoothed temperature data. The average regional annual temperature for the period 1948-2006 was 18.13°C. The warmest year was 1957, with an average annual temperature of 19.24°C; the coolest year was 1976, with an average annual temperature of 17.04°C. The six warmest years (1957, 1949, 1954, 1950, 1952, and 1953) all fall before 1960; the six coolest years (1976, 1996, 1964, 1969, 2001, and 1961) all occur after 1960. The six most recent calendar years, 2001-2006, are respectively the fifth, 41st, 22d, 28th, 31st, and 34th coolest of the 59 years we studied.

During most of the year, average monthly temperatures are relatively stable, showing a remarkably small degree of variation from year to year. The variance in average temperatures for each of the summer months of June, July, and August is less than 1°C for the entire period under consideration. However, temperature patterns for the three winter months of December, January, and February are far more erratic. The variance in January

temperatures is 7.26°C, and is greater than or equal to 4°C in each of the other two winter months.

Closer inspection indicates that while these three months are the coldest of the year, in none of them would a daily high temperature of 21°C be considered out of the ordinary. In fact, in Montgomery, Alabama, 196 of the 902 winter days (21.7%) between 1997 and 2006 had a maximum temperature greater than or equal to this mark. On the other hand, 283 of these days (31.4%) saw a minimum daily temperature at or below the freezing mark (0°C).

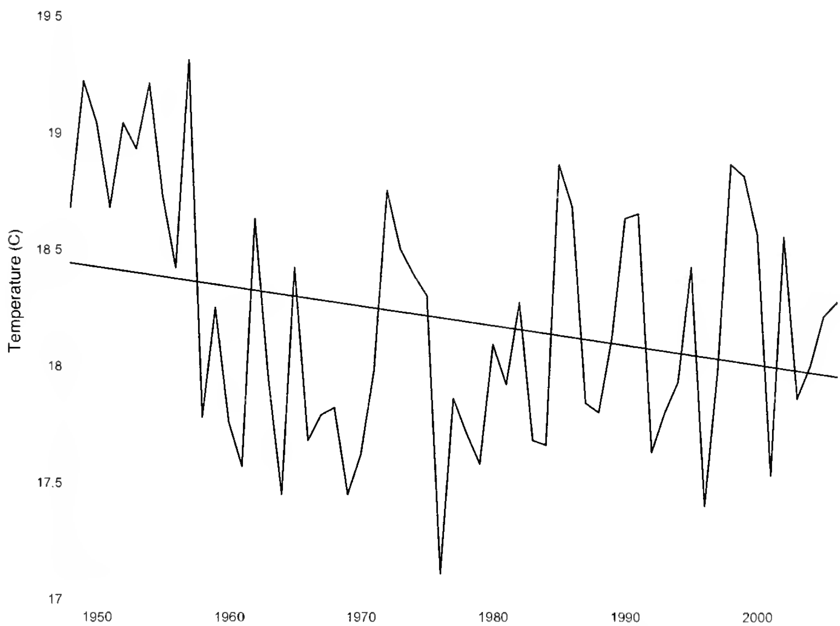

Figure 2: Regional average annual temperatures (unsmoothed), 1948-2006, with best-fit line.

Turning our attention to 10-year moving average data, we note an overall downward trend in average temperature for the years 1957-2006 (r^2=0.082). Regression calculations indicate that the average annual temperature decreased at a rate of just under 0.05°C per decade. (See Fig. 3) If we divide the years under analysis into two twenty-five year sub periods, 1957-1981 and 1982-2006, two very different and distinct temperature patterns emerge. During the first period, we discover an overall downward trend (r^2=0.61). Regression analysis indicates that during this period, average temperatures decreased at a rate of just under 0.35°C per decade. On the other hand, during the second period, temperatures rose at a rate of just over 0.1°C per decade (r^2=0.56). (See Fig. 4) Somewhat surprisingly, at a 95% level of confidence, we found no statistical support to indicate that

the mean temperature of one sub period was different from the mean of the other. The mean of the averaged temperatures during the first sub period was 18.10°C with a variance of 0.11°C; during the second sub period the mean was 18.03°C, with a variance of 0.01°C.

In summary, our study of the regional 10-year moving average data indicates that the 1950s were warmer than the years that followed. Average temperatures dropped significantly until the 1970s, at which point they began a slow but steady recovery. They have not yet retuned to the levels attained in the 1950s. As a result, the temperature trend line for the period 1957-2006 has a negative slope, caused primarily by the sharp decrease in temperature levels during the first half of the period under analysis.

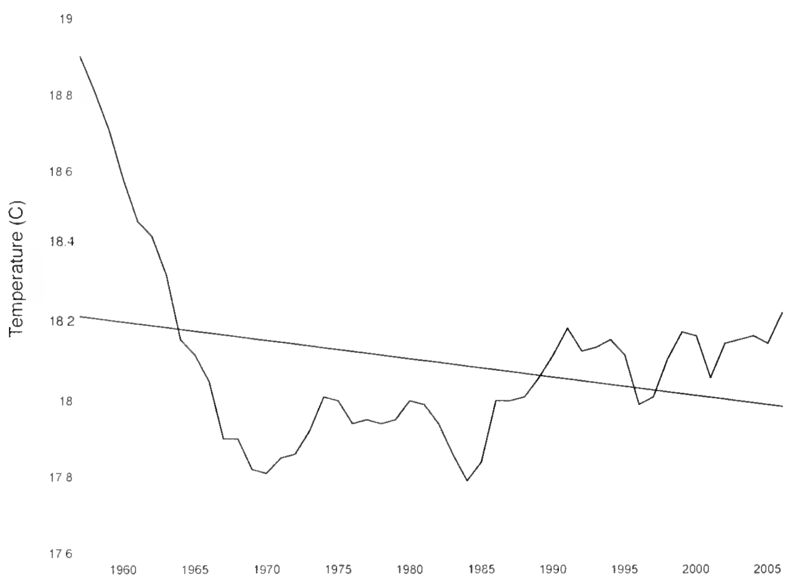

Figure 3: 10-year moving average annual temperatures, 1957-2006, with best-fit line.

Seasonal Temperatures:

Figure 5 depicts unsmoothed seasonal temperature data for the region; figure 6 illustrates what happens when the data is smoothed by applying 10-year moving averages to the data.

Focusing our attention on the 10-year moving average models, at a 95% level of confidence, we can not determine if winter, summer, and fall temperatures are either

increasing or decreasing during the period under analysis. On the other hand, we were surprised to find a significant drop of just over 0.1°C per decade in average spring temperatures (r^2=0.67). During the most recent 10-year period, however, this seasonal trend seems to have reversed. From 1997-2006, spring temperatures rose at a healthy rate of just over 0.3°C per decade (r^2=0.50).

Rainfall:

Beginning with raw, unsmoothed data, we found that the regional average rainfall during the period 1948-2006 was 138.4 cm. The wettest year was 1975, with 193.31 cm of total precipitation; the driest year was 1954 with only 96.7 cm. The six wettest years were 1975, 1983, 1964, 1948, 2003, and 1973. The six driest years were 1954, 2000, 1968, 1981, 2006, and 1951. The six most recent calendar years, 2001-2006, were the 32nd, 17th, 55th, 29th, 37th, and fifth driest years respectively of the 59 years studied.

Rainfall is distributed relatively evenly over the year, with slightly less precipitation occurring during the fall season. On average, 26.8% of annual precipitation occurs during the winter, 27.0% in the spring, 26.1% in the summer, and 20.1% in the fall. The two rainiest months are March, with 15.63 cm of precipitation, and July, with 14.35 cm. The nature of the rainfall in these two months is quite different, with March rains associated with warm and cool fronts, while in the summer much of the rain is associated with afternoon thunderstorms.

Figure 4: Regional 10-year moving average annual temperatures, 1957-1981 and 1982-2006, with best fit lines.

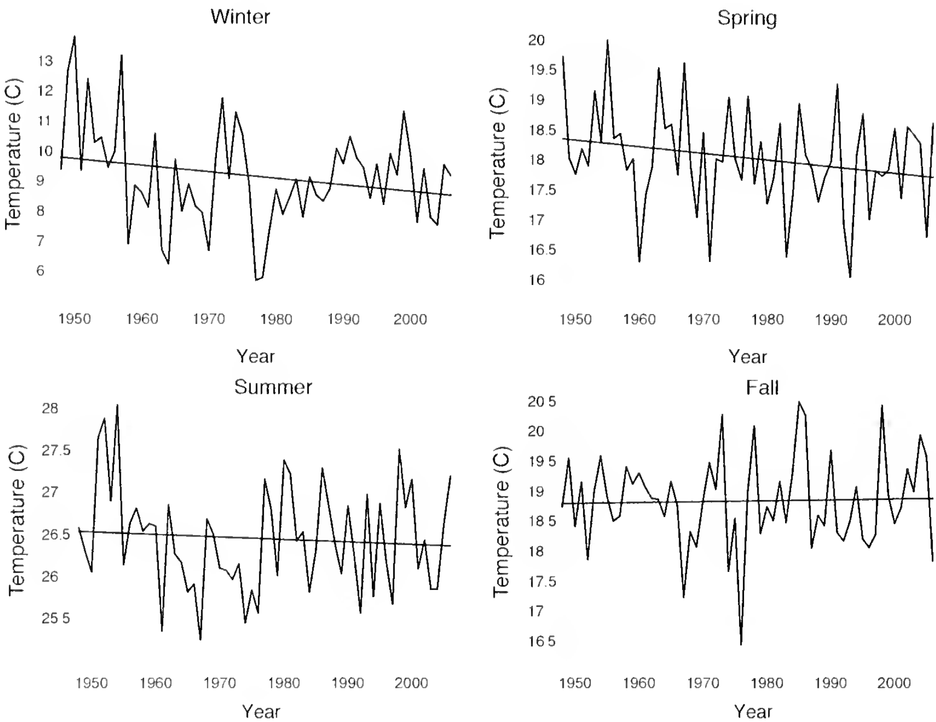

Figure 5: Average seasonal temperatures (unsmoothed), 1947-2006, with best fit lines.

We note, however, that year-to-year precipitation is extraordinarily variable. We calculated monthly variances ranging from 12.88 cm for the month of August to 42.16 cm for March. With the exception of August, every month of the year has a calculated precipitation variance in excess of 21 cm.

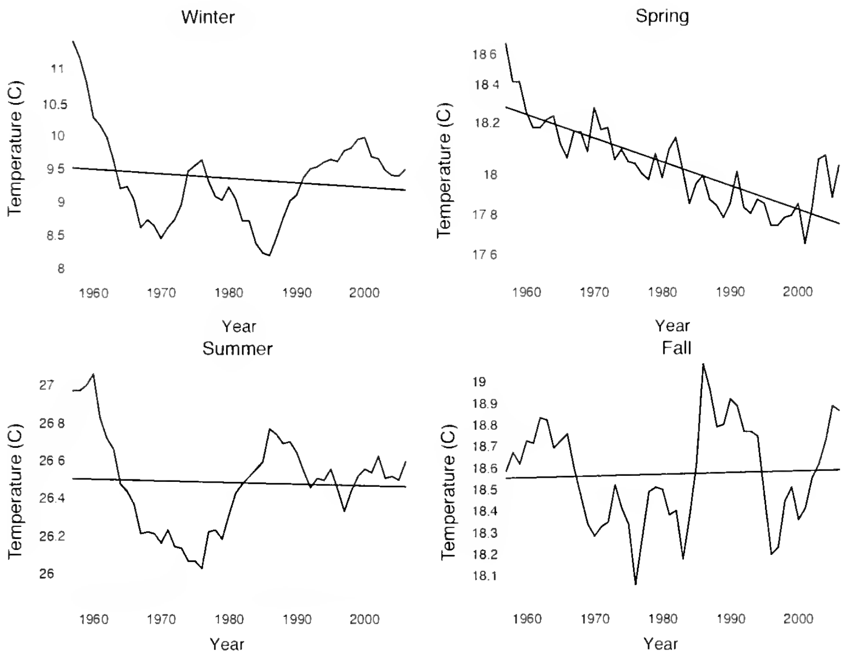

Figure 6: 10-year moving average seasonal temperatures, 1957-2006, with best-fit lines.

Turning our attention to 10-year moving averages, we note that total annual rainfall has increased at a slow but statistically significant rate. Regression analysis indicates that total annual precipitation has increased 1.63 cm per decade since 1957 (r^2=0.17). Since data from the most recent 10-year period indicates that rainfall has been decreasing at a rate of 13.2 cm per decade (r^2=0.77), we are unsure as to whether the increasing trend can be sustained into even the near future. (See Fig. 7)

Seasonal Rainfall:

Data for each of the seasons is summarized in Fig. 8. At a 95% level of confidence, we could not determine whether winter or spring precipitation was increasing or decreasing or constant during the period under analysis. We note that during the 10-year period 1957-1966, total winter precipitation rose at a rate of 6.47 cm per decade (r^2=0.76), and during the 10-year period from 1997-2006, it has fallen at the rate of 9.53 cm per decade (r^2=0.88).

We also note that four of the ten rainiest spring seasons occurred during the years 1973-1980. This cluster of higher than average data is clearly reflected by a large peak occurring in the middle portion of the precipitation graph.

Despite a marked drop occurring in the mid-1980s, summer precipitation has increased at a rate of 0.6 cm per decade since 1957 (r^2=0.19).

The most remarkable season for precipitation is fall, where an increase of more than 6 cm (about 25%) in rainfall has been observed. Consonant with that finding, we discovered that three of the ten rainiest fall seasons have occurred during the last 10-year period, while five of the driest fall seasons occurred prior to 1960. This finding may be of interest for future studies, as the nature of fall rains are varied, with afternoon thunderstorms, frontal systems, and tropical activity all contributing. Much of the increase has been in November rainfall, which indicates it is unlikely that tropical activity is the main driving force for the increasing fall rains.

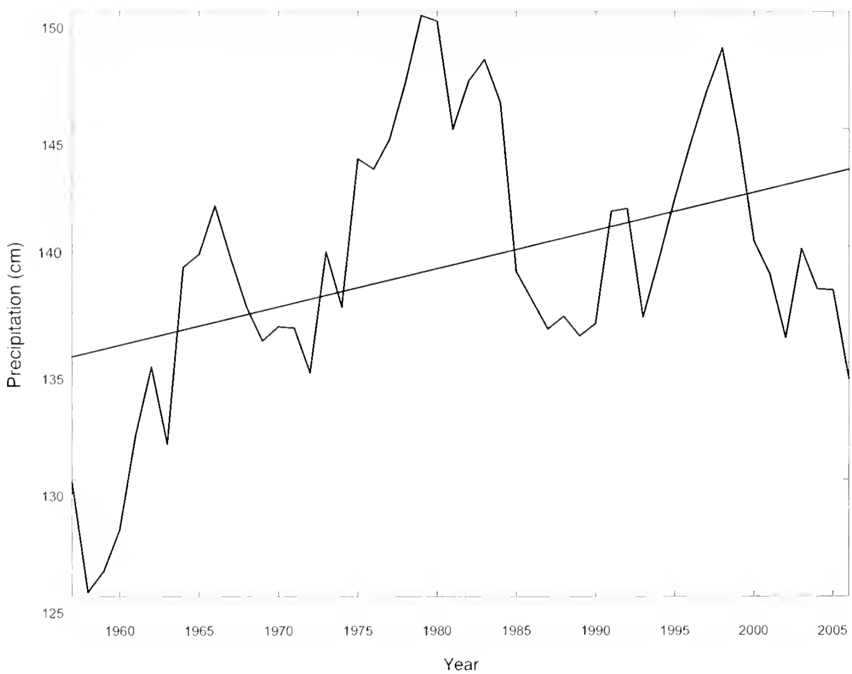

Figure 7: Regional 10-year moving average annual precipitation, 1957-2006, with best-fit line.

Correlations:

Some interesting insights into how our regional weather "works" can be found by studying correlations between our various smoothed data sets. We summarize this information in table 2.

Our first finding is that annual average temperature and annual precipitation are negatively correlated (r^2=0.43). This relationship is illustrated in Fig. 9.

Looking at seasonal data, we found that average summer temperature is a reasonable predictor of annual average temperature (r^2= 0.58). Summer temperature is also positively and significantly correlated to both fall average temperature (r^2=0.33) and winter average temperature (r^2= 0.24). In terms that our freshman students would understand, the data tells us that warmer summers suggest warmer years, warmer falls, and warmer winters. (See Fig. 10)

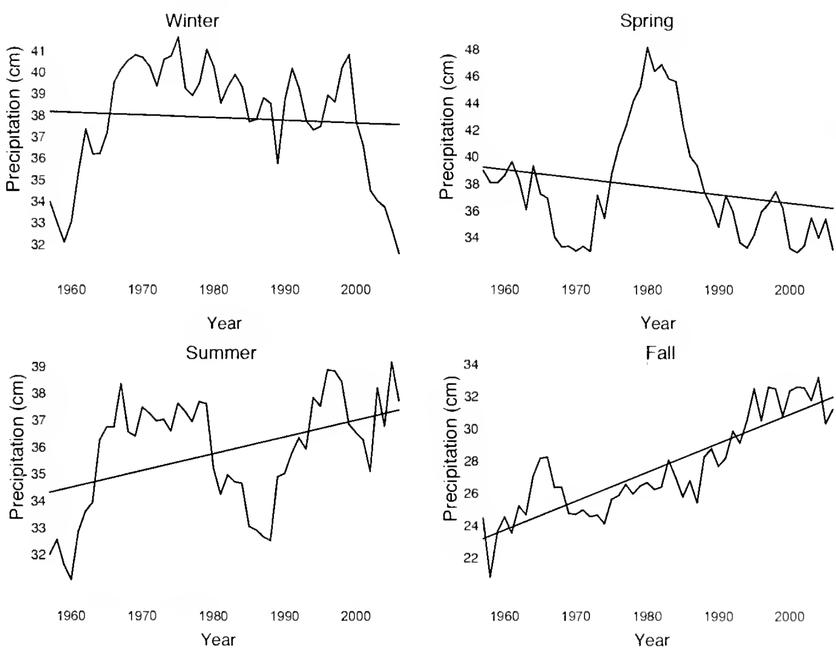

Figure 8: Seasonal 10-year moving average precipitation, 1957-2006, with best-fit lines.

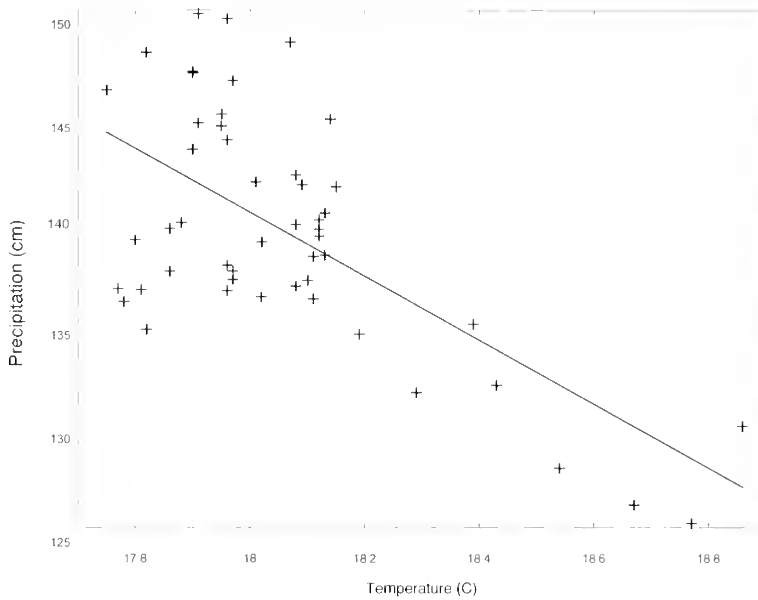

Figure 9: Correlation. Regional 10-year moving average annual temperature and regional 10-year moving average precipitation, 1957-2006, with best-fit line.

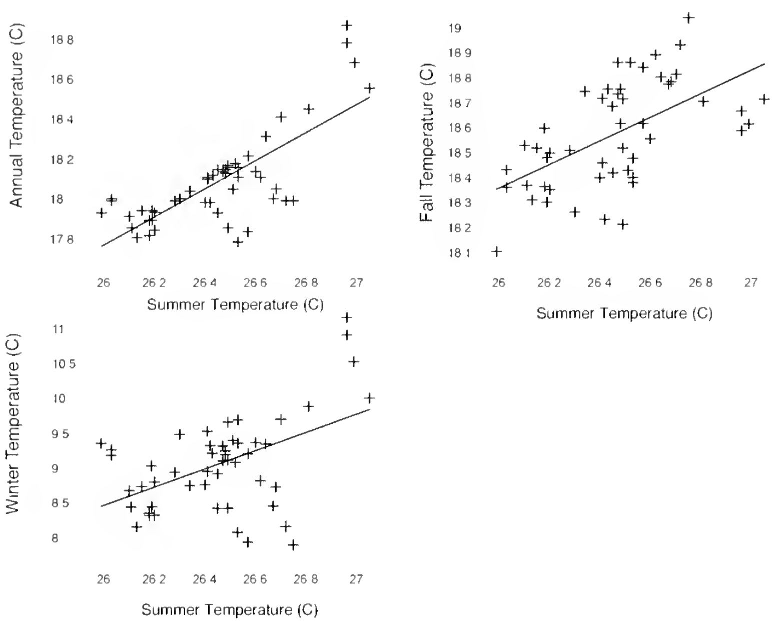

Figure 10: Correlation. Summer 10-year moving average temperature with 10-year moving average annual temperature, 10-year moving average fall temperature, and ten year moving average winter temperature, 1957-2006, with best-fit lines.

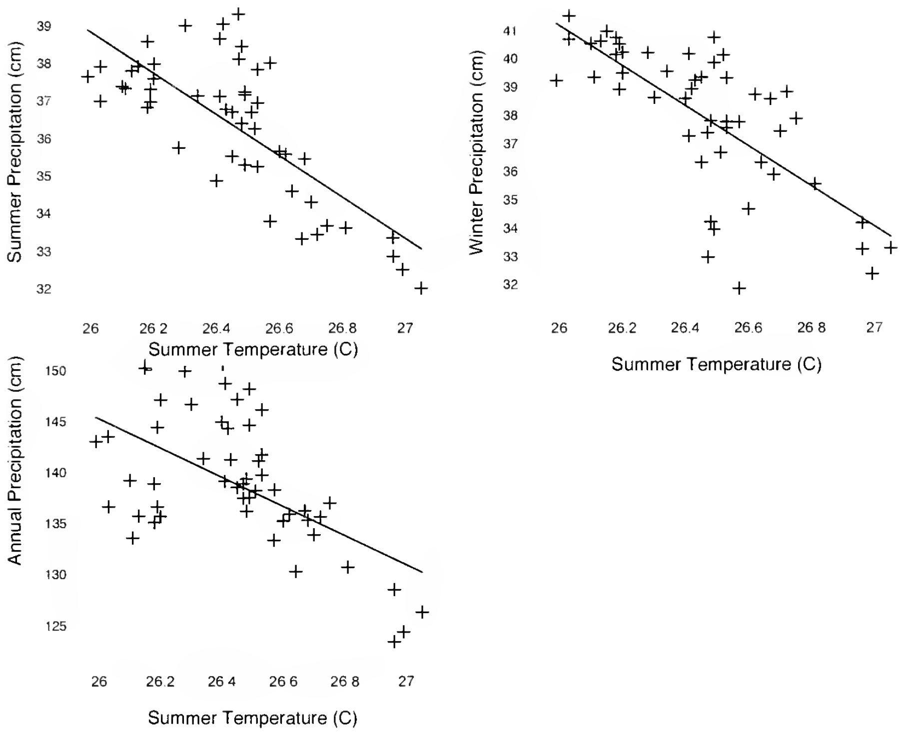

Figure 11: Correlation. Summer 10-year moving average temperature with 10-year moving average summer precipitation, 10-year moving average winter precipitation, and 10-year moving average annual precipitation, 1957-2006, with best-fit lines.

Table 2. Regional 10 year averages data correlations, 1957-2006. The first entry is the Pearson correlation coefficient and the second is the calculated p-value.

	Annual temp.	Annual precip.	Winter temp.	Winter precip.	Spring temp.	Spring precip.	Summer temp.	Summer precip.	Fall precip.
Annual	-0.656								
precip.	0.000								
Winter	0.887	-0.418							
temp.	0.000	0.003							
Winter	-0.713	0.638	-0.549						
precip.	0.000	0.000	0.000						
Spring	0.471	-0.538	0.293	-0.245					
temp.	0.001	0.000	0.039	0.087					
Spring	-0.107	0.474	-0.147	0.196	0.103				
precip.	0.459	0.000	0.306	0.171	0.474				
Summer	0.759	-0.588	0.488	-0.715	0.166	0.021			
temp.	0.000	0.000	0.000	0.000	0.248	0.883			
Summer	-0.515	0.551	-0.216	0.347	-0.384	-0.321	-0.751		
precip.	0.000	0.000	0.000	0.014	0.006	0.023	0.000		
Fall	0.401	-0.445	0.036	-0.443	0.023	-0.173	0.574		
temp.	0.004	0.001	0.805	0.001	0.976	0.230	0.000	0.006	
Fall	-0.168	0.407	0.002	-0.122	-0.723	-0.330	-0.031	0.506	0.008
precip.	0.245	0.003	0.992	0.398	0.000	0.019	0.831	0.000	0.953

Another notable finding is that summer temperature is also correlated, negatively and significantly, with summer precipitation (r^2= 0.56), winter precipitation (r^2=0.51), and annual precipitation (r^2=0.35). Thus, warm summers correlate to drier summers, drier winters, and drier years. (See Fig. 11)

Average winter temperature is also an important predictor of regional weather behavior. It shows a strong correlation to average annual temperature (r^2=0.79). To a lesser extent, it is also an indicator of summer and spring temperatures (r^2=0.24 and r^2=0.09, respectively). It also correlates negatively with winter precipitation (r^2=0.30) and total precipitation (r^2=0.17). (See Figs. 12-13) Thus, a warm winter correlates to a warm year, dry winter, and dry year.

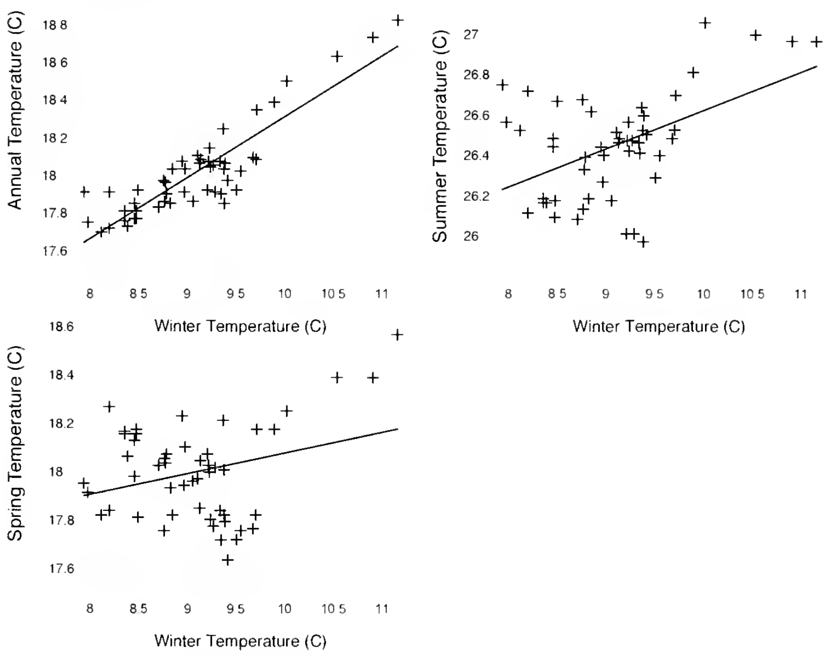

Figure 12: Correlation. Winter 10-year moving average temperature with 10-year moving average annual temperature, 10-year moving average summer temperature, and 10-year moving average spring temperature, 1957-2006, with best-fit lines.

DISCUSSION

Changing weather patterns can have a significant impact on Alabama's economy. While it seems paradoxical, a warm winter can have a negative effect on the state's productivity due to crop losses resulting from a late spring thaw (Lianhong, et. al., 2008). Changing rainfall patterns can lead to crop failures, fires, and floods.

In addition, many Alabama crops have a specific number of chilling hours (that is, the number of hours below 17°C needed for optimal yields). For example, the Alabama Cooperative Extension System has developed a guide to peach farming in Alabama in which special attention is paid to selecting proper chilling requirements for each region of the state. In northern Alabama, farmers are encouraged to select varieties that require more than 850 chilling hours, while farmers in central Alabama are recommended to plant varieties requiring only 750 hours (Powell, 1998).

Many industries are dependent upon steady and predictable water levels and stream flows. In addition, reliable rainfall is often of critical importance to growers of field crops. Lack of water is often a limiting factor for urban expansion and population growth as well.

Alabama's climate is dynamic, changing year to year. By smoothing the raw temperature and precipitation data, we temper some of this variability so that underlying trends are made more readily apparent. Since our primary concern in this study was to uncover trends taking place during the years 1948-2006, we freely employed regression techniques to analyze the information. We caution the reader not to extrapolate from these models in an attempt to forecast long-term future weather trends.

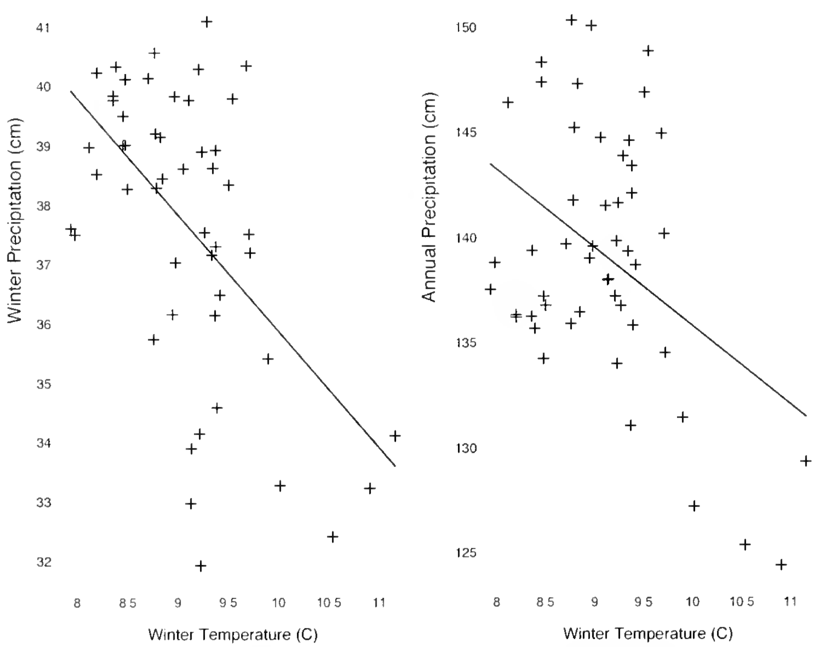

Figure 13: Correlation. Winter 10-year moving average temperature with 10-year moving average winter precipitation and 10-year moving average annual precipitation, 1957-2006, with best-fit lines.

In summary, we believe the following to be the most intriguing and significant weather trends in our region during the period 1948-2006:

1. Regionally, 10-year average temperatures decreased slightly while average precipitation levels increased.
2. During this time period, summer and winter temperatures are significantly related to both annual and seasonal measures of rainfall and temperature.
3. Regional average spring temperatures decreased during the period 1957-2006, but have shown a rapid and significant increase since 1997.
4. Regional average fall precipitation has significantly increased since 1957.

It is important to note that overall the changes in temperature and rainfall have been fairly modest. The average temperature change is detectable, and worth monitoring, but overall fairly small. Other places in the world, such as Alaska, are showing considerable changes which will have profound effects on their ecosystems. Based on our analysis of the past 59 years of weather data, Alabama has not seen a drastic change. The most significant change over the past 50 years has been the substantial (25%) increase in fall precipitation. Further research is needed to determine what, if any, change on Alabama's water resources or possibly flora and fauna will come from the climatic changes seen over the past 50 years, and to see if these patterns continue or new ones emerge.

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TEMPORAL VARIATION IN SEX ALLOCATION OF WHITE-TAILED DEER

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ABSTRACT

For several decades the Trivers-Willard hypothesis has been at the forefront of debates concerning differential investment of females into offspring sex. The main consistency in these debates has been the focus on how female condition influences offspring sex: very few studies have deviated from this line of investigation. We hypothesized that factors other than female condition may influence offspring sex and investigated how conception date influences offspring sex using white-tailed deer (*Odocoileus virginianus* Zimmerman) as a model. We found that during the first half of the breeding season (prior to 22 Jan) more males were conceived, while more females were conceived during the second half of the breeding season (after 22 Jan). We suggest that time available for development of offspring during their first year is an important factor in determining offspring sex. Offspring born early during the conception period have more time available for development relative to their late-born counterparts, and thus have greater potential for large body size and dominance later in life, important factors in the reproductive success of males. As a result, females conceiving early will maximize fitness by producing male offspring who will have more opportunity for growth prior to their first winter. Females conceiving later should invest in daughters because daughters have less variability in lifetime fitness and greater probability of achieving some measurable reproductive success; late-born sons will be at a competitive disadvantage when breeding. We hypothesize that in species where competition for mates is high and lifetime reproductive success of the sex competing for mates varies considerably, that females who conceive early will maximize fitness by investing in the sex that competes
for access to mates.

INTRODUCTION

Since Trivers and Willard (1973) published their hypothesis concerning individual variation in investment of sons and daughters, considerable attention has been directed towards understanding what factors drive this differential investment in ungulates. If a female has the ability to choose a reproductive strategy that maximizes future fitness, the framework for such a strategy must balance risk and reward, where both risk and reward are measured in production of grandchildren. Trivers and Willard (1973) suggested that females in poor condition should invest in daughters because female offspring require less parental investment, and female offspring raised by poor mothers will reproduce whereas male offspring likely will not. This hypothesis has been found to hold true for a variety of ungulate species (Clutton-Brock et al., 1984; Rutberg, 1986; Kojola and Eloranta, 1989; Kucera, 1991), yet in some studies (Verme, 1983; Skogland, 1986; Hewison and Gaillard, 1996) the opposite has been found: females in good condition produce more daughters than sons. The local resource competition hypothesis (Clark, 1978; Silk, 1983) suggests that these alternative findings are due to competition for resources rather than maternal condition. Females in good condition should invest more heavily in the sex that does not disperse (females), while those in poor condition should invest more heavily in the dispersing sex (males) to reduce future competition.

These opposing theories have led to some confusion regarding the mechanism underlying variation in secondary sex ratios of ungulates. We will show that until now, a powerful yet simple hypothesis for influencing secondary sex ratios has been mostly overlooked as an alternative or complementary factor in influencing offspring sex. Date of conception has the potential to explain considerable variation that can be found in patterns of offspring sex ratios in ungulates. Trivers and Willard (1973) based their hypothesis on the assumption that mothers in better condition should invest more in costly sons because these mothers would have increased resources available to produce successful sons (Hewison and Gaillard, 1999). Sons are more costly to produce than daughters because of greater rates of growth (Clutton-Brock et al., 1982; Wilkinson and van Aarde, 2001), and greater milk consumption (Clutton-Brock et al., 1982). Total resources available to a neonate during its first year, however, also depend on when it is born: individuals born early have more time available to accumulate resources before winter than individuals born later. Males born earlier may demonstrate greater body size (Green and Rothstein, 1993), antler development (Schmidt et al., 2001), and dominance (Green and Rothstein, 1993) throughout life than their later-born counterparts, ultimately leading to greater reproductive success (Clutton-Brock et al., 1979; Gibson and Guinness, 1980). In general, males conceived late in the breeding season may be at a competitive disadvantage, suggesting that females that conceive later should produce daughters. Our theory concerning the effects of conception date on offspring sex ratios differs from Trivers and Willard (1973) in that offspring sex is influenced by time available for development, rather than an individual female's ability to provide resources to her offspring.

In this study, we investigated the relationship between date of conception and offspring sex ratio in white-tailed deer (*Odocoileus virginianus* Zimmerman). Saalfeld et al. (2009) reported that female white-tailed deer in Michigan differentially invested in sons early in the breeding season, and produced more females as the breeding season progressed. We similarly hypothesized that there would be a greater proportion of male than female offspring born early during the breeding season, and there would be an increase in the proportion of female offspring born as the breeding season progressed in Alabama. White-tailed deer are a unique model to examine factors influencing secondary sex ratios of offspring; they have reproductive characteristics that meet assumptions of the Trivers-Willard model (Trivers and Willard, 1973; Hewison and Gaillard, 1999) and theoretically should display fetal sex ratios where females in good condition invest more heavily in sons. However, the preponderance of data with white-tailed deer suggest that females in good condition produce more daughters than sons (Verme, 1983; 1985), which lends credence to the local resource competition hypothesis.

MATERIALS AND METHODS

The data was analyzed on secondary sex ratios of female white-tailed deer ($n = 472$) collected during 1995-2002 by the Alabama Division of Wildlife and Freshwater Fisheries as part of their spring-summer reproductive surveys. Using firearms, the Division annually collected 100-200 female deer from management areas throughout the state of Alabama. Following collection, they examined fetuses and determined age (days) and sex according to Hamilton et al. (1985). Date of conception was determined by backdating from the date of collection. Collections took place during May and June, as the peak of breeding for Alabama deer normally occurs during January (Causey, 1990) with births in late summer (late July – early September). We subdivided fetuses for which we had determined age into 6 groups (prior to 7 Jan, 7 Jan – 15 Jan, 16 Jan – 21 Jan, 22 Jan – 27 Jan, 28 Jan – 5 Feb, and after 5 Feb) of comparable sample size (n = 187 to n = 234) based upon conception date. These 6 periods were selected only to make sample sizes within each period as close to equal as possible. We tested whether sex ratios differed from equality and compared sex ratios between sampling periods using a Pearson chi-square (Wilson and Hardy, 2002).

RESULTS

Table 1. Sex ratio of fetuses collected from female white-tailed deer during six periods of conception during the breeding season in Alabama, USA, during 1995-2002.

Conception period					
#	Start	End	# of males	# of females	% males
1	------	6 Jan.	129	105	55.12
2	7 Jan.	15 Jan.	123	105	53.95
3	16 Jan.	21 Jan.	120	97	55.30
4	22 Jan.	27 Jan.	103	113	47.69
5	28 Jan.	5 Feb.	95	110	46.34
6	6 Feb.	------	100	87	53.48

Mean date of conception was 21 January ($n = 778$; SE = 0.594), and mean number of fetuses per gravid doe was 1.749 ($n = 780$; SE = 0.019). We detected a sex ratio for the entire study that was slightly skewed towards males (52.1%), but this did not differ from equality ($X^2 = 1.0913$; $P = 0.296$). Sex ratios for the six conception periods did not differ from equality ($P > 0.25$; Table 1), but we did detect differences in proportions of males when comparing periods. When comparing the sex ratio of the first 3 periods against that of the last 3 periods, we found that a greater proportion of males (54.79%; $X^2 = 4.28$; $P = 0.039$) were conceived during the first half of the breeding season than during the second half (49.01% males).

DISCUSSION

Our data support our original hypothesis that conception date influences sex ratio of offspring in white-tailed deer: females differentially invest (e.g., tend to produce males or females) in male and female offspring at different times during the breeding season based partly upon projected time available for postnatal development. More male deer were conceived in the first half of the breeding season, and more females were conceived later in the breeding season. Although this pattern has been documented in a few mammals, specifically elk (Kohlmann, 1999), red deer (Clutton-Brock et al., 1982) (*Cervus elaphus* Linnaeus), and some seal species (Coulson and Hickling, 1961; Stirling, 1971), only one study (Saalfeld et al. 2009) has noted the significance of this pattern relative to the theoretical framework of Trivers and Willard's (Trivers and Willard, 1973) hypothesis. Saalfeld et al. (2009) documented a pattern similar to what was found in this study, where females invested more heavily in male offspring early in the breeding, and increased investment in females later in the breeding season. White-tailed deer are a temperate species that experience poor food availability during winter throughout their range and a marked decline in growth after 14 weeks of age, followed by little or no growth during

winter (Ullrey et al., 1967). As a result, females who conceive early during the breeding season maximize opportunity for growth of their offspring. Because body size of juvenile male deer at the end of the first year is associated positively with lifetime reproductive success (Suttie, 1983), females that conceive early will maximize fitness by producing sons. However, environmental constraints (e.g., poor food availability, cold temperatures, etc.) set a limit on how early successful birthing, and hence breeding, can begin. After the peak of the breeding season (22 Jan), females maximize fitness by producing daughters. In polygynous species, variation in fitness of daughters is less variable than that of sons: most females will reproduce as they do not compete for access to mates as do males (Clutton-Brock et al., 1982). As a result, females maximize fitness in late conceptions by producing daughters that are almost assured of successful reproduction, rather than males that may not be reproductively competitive because of inferiorities in dominance, body mass, and antler development.

Our proposed theory has some similarities to results that have been previously reported for opossums (*Didelphis virginiana* Kerr) and some avian species. Wright et al. (1995) found that female opossums produced a greater proportion of males in their first litter of the season and a greater proportion of females in their second litter. The first-cohort advantage hypothesis (Wright et al., 1995) suggests that male opossums born in the first litter (weaned in May) achieve greater reproductive success during their first breeding season because of greater body size than males born in second litters (weaned in August). Undoubtedly, the 3 months of additional time available for growth of first litter males should aid in physical development and allow for greater success when competing for females during their first breeding season. However, most large mammals differ in that there is only one cohort produced during each calendar year, and thus there is only one breeding period. As a result, female white-tailed deer must adjust their strategy for production of male and female offspring based upon timing of conception within a single breeding season, rather than between breeding seasons.

In some avian species, particularly raptors, seasonal shifts in sex ratios have been documented. Dijkstra et al. (1990) found that the sex ratio of European kestrel (*Falco tinnunculus* Linneaus) broods decreased as laying dates became later. Because male reproductive success is greater for those born early, early broods should be biased towards males to maximize fitness of the mother. Similar results have been reported for American kestrels (*Falco sparverius* Linneaus), where early in the breeding season, most sex-biased broods were biased towards males and the reverse was true later in the breeding season (Smallwood and Smallwood, 1998). However, data from several other raptor species have suggested that female offspring tend to predominate earlier in the breeding season and males later (Olsen and Cockburn, 1991; Zijlstra et al., 1992; Leroux and Bretagnolle, 1996). These discrepancies are explained by Daan et al. (1996), who suggested that in raptors, the influence of early birth date on male and female offspring differs by species. They state that the sex whose age at first breeding is most strongly correlated with an early birth date should predominate in early clutches.

Sex ratios near the end of the breeding season may depart from our proposed theory of

female investment. Rather than mothers continuing to invest in female offspring near the conclusion of the breeding season, our data suggest they once again produce more sons than daughters. As the breeding season comes to a close, females appear to follow a pattern similar to that predicted by the local resource competition hypothesis (Clark, 1978; Silk, 1983). Both late-born male and female offspring normally have lower probability of survival and successful reproduction than their earlier-born counterparts (Smith and Anderson, 1998; Keech et al., 2000). Therefore, at some point during the conception period it may be in the best interest of the mother to produce the dispersing sex (e.g., a son) because of fitness costs associated with producing a poor daughter that will compete for resources. Juveniles are challenged during their first 6 months of life with acquiring resources (e.g., nutrients) needed for both growth and energetic reserves for winter survival. Early-born ungulates have opportunity for growth prior to establishing energetic reserves, while late-born fawns must build energetic reserves during this period of growth. As a result, late-born offspring tend to have lower body mass during winter, which can result in reduced over-winter survival (Clutton-Brock et al., 1987; Takatsuki and Matsuura, 2000) or cause them to experience long-term deficiencies in body mass, antler development, and reproductive success (Green and Rothstein, 1993). Because both sons and daughters that are born extremely late will experience constraints on growth, survival, and reproduction, females should invest in the sex that will produce the greatest potential payoff in terms of grandchildren, but cost the least in terms of competition for resources for her, her past and future offspring, and her grandchildren. Because projected survival and expected lifetime reproductive success are below average for these late-born offspring (Clutton-Brock et al., 1987; Green and Rothstein, 1993; Takatsuki and Matsuura, 2000), it may be counterproductive to produce a poor daughter that will establish a sympatric home-range and compete for resources with the mother and other relatives. Late-born offspring, both male and female, that do breed will likely experience poor reproductive success relative to their counterparts, resulting in a low "payoff" to the mother in terms of grandchildren. As a result, it may be in the best interest of late-conceiving females to invest in male offspring that will disperse, which is similar to that proposed by the local resource competition hypothesis (Clark, 1978; Silk, 1983), and not compete for resources during times of food scarcity because costs of resource competition may outweigh benefits in terms of grandchildren when producing late-born daughters. Saalfeld et al. (2009) documented a similar pattern in white-tailed deer where investment in the dispersing gender increased during the end of the reproductive period.

The consideration of conception date as an explanatory variable in variation of offspring sex is a significant departure from the hypothesis of Trivers and Willard (1973). In species where there exists considerable difference in lifetime reproductive success between sexes, females who conceive early should invest in the sex that has the greatest variability in lifetime reproductive success. In most cases, these will be species in which one sex competes for access to mates. Normally, when mating success is highly variable within a sex, dominance, and hence body size and development of physical attributes will be important factors in determining success. Early-born individuals possess greater

potential relative to late-born counterparts to maximize body size because of greater time available for development early in life. Of course, numerous factors influence lifetime fitness, including habitat quality, genetics, etc., and any projections of fitness assume that these factors are equal.

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BODY TEMPERATURES OF OVER-WINTERING COTTONMOUTH SNAKES: HIBERNACULUM USE AND INTER-INDIVIDUAL VARIATION

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ABSTRACT

Environmental temperatures affect the physiology, ecology and behavior of reptiles due to the temperature dependence of biochemical reactions and the inability of reptiles to metabolically maintain constant temperatures. Consequently, periods during which environmental temperatures are extreme or variable (e.g. winter) may be particularly stressful for reptiles. However, few studies have reported body temperatures of reptiles during the winter. We studied body temperatures of Cottonmouth snakes (*Agkistrodon piscivorus*) during the winter in eastern central Alabama. We compared Cottonmouth body temperatures that were measured using implanted temperature-sensitive radio transmitters to air, soil and water temperatures to determine whether snakes conformed to environmental temperatures. We also compared body temperatures among snakes to determine whether individual snakes differed in their body temperatures. Results indicate that snakes maintained mean body temperatures near the upper range of environmental temperatures. Additionally, individuals maintained different body temperatures during over-wintering. These results provide evidence that snakes select hibernacula (the sites where the snakes spend the winter) or employ thermoregulatory behaviors to maintain relatively warm winter body temperatures and that different individuals experience different body temperatures during the winter.

INTRODUCTION

Environmental temperature profoundly affects the physiology, ecology and behavior of many reptiles (Gibson and Falls 1979, Plummer 1993, Beaupre 1995, Luiselli and Akani 2002, Herczeg et al. 2008, Kapfer et al. 2008). This is due to the temperature-dependence of biochemical reactions and the inability of reptiles to metabolically maintain constant body temperatures as environmental temperatures change (Seebacher and Franklin 2005). Body temperatures affect the rates of diverse physiological processes including digestion (Wang et al., 2003), neural activity (Teng and Wilkinson, 2003), metabolism (Dorcas et al. 2004), immune function (Cooper et al. 1985), and growth and development

(O'Donnell and Arnold 2005). Consequently, reptiles must maintain body temperatures within a physiologically determined range in order to maintain homeostasis. During parts of the year when environmental temperatures are mild, animals maintain stable body temperatures through behavioral thermoregulation–moving between microhabitats to achieve body temperatures within a desired range (Hertz et al., 1993). However, thermoregulation is much more difficult during periods of the year when environmental temperatures are extreme and variable (e.g. winter for temperate species, Blouin-Demers and Weatherhead 2002). During the winter, reptiles are faced with three options: conform to environmental temperatures, attempt behavioral thermoregulation, or use hibernacula (wintering sites) that offer favorable winter temperatures.

Many studies have reported body temperatures of reptiles during parts of the year when they are active (i.e. warm spring and summer months for temperate species, Plummer 1993, Blouin-Demers and Weatherhead 2002, Crane and Greene 2008, Herczeg et al. 2008, Kapfer et al. 2008). Few studies, however, have reported body temperatures of reptiles during inactive periods when environmental conditions are harsh and variable (e.g., during the winter for temperate species, Blouin-Demers and Weatherhead 2001, Gregory 1982, Himes et al., 2006) despite evidence suggesting that winter body temperatures may be directly linked to over-wintering survival. Low body temperatures during over-wintering can cause animals to freeze to death (Blem and Blem, 1995, Shine and Mason 2004). High temperatures, on the other hand, elevate metabolic rates and may cause animals to exhaust energy stores and die of starvation (Blem and Blem 1995, Blem 1997). The paucity of published data on over-wintering body temperatures of reptiles makes it difficult to determine the importance of this period in determining their physiology, behavior and survival.

In order to more fully characterize winter body temperatures of reptiles and evaluate the possibilities of winter thermoregulation and hibernaculum selection, we studied over-wintering body temperatures of free-ranging Cottonmouth snakes, *Agkistrodon piscivorus* (Lacépède). This species has served as a model in numerous studies of reptilian physiology, behavior and thermal biology (e.g. Blem and Blem 1995, Blem 1997, Crane and Greene 2008, Glaudas et al. 2007, Hill 2004, Hill and Beaupre 2008, McCue and Lillywhite 2002, Wharton 1969); however, to our knowledge, no study has reported over-wintering body temperatures of Cottonmouths. Specifically, we sought to address two questions about over-wintering Cottonmouths at our study site: 1) Do Cottonmouths (a) conform to dominant environmental temperatures during the winter, (b) actively thermoregulate or (c) use hibernacula with thermal properties that differ from the dominant environmental media (air, water, soil)? 2) Do different individuals experience different body temperatures during the winter? Since air, water and soil temperatures at our study site frequently drop below zero degrees Celsius during winter, we predicted that Cottonmouths would actively thermoregulate or use warmer microhabitats to avoid lethal body temperatures. Additionally, we were interested in inter-individual differences in body temperature. Such differences could point to differences in physiological states of individuals during this particularly harsh time in their life history (Gregory 1982). For example, body temperature

differences among individuals can cause differences in the energetic cost of over-wintering because metabolic rates increase as a function of increasing temperature (McCue and Lillywhite 2002). The ability to maintain favorable body temperatures during the winter may be an important trait linked to over-wintering survival.

We addressed our questions by measuring field body temperatures of Cottonmouths from a population in eastern Alabama during the late-fall, winter, and early spring of 2005-2006. To test our prediction that snakes actively thermoregulate or use thermally favorable hibernacula rather than conforming to dominant environmental temperatures, we compared snake body temperatures (measured using temperature-sensitive radio telemetry) to air, water and soil temperatures measured with a quick-read thermometer at the site where each snake was located. To determine whether among-individual variation in body temperature existed in our study population, we compared mean body temperatures among snakes.

MATERIALS AND METHODS

We conducted this study from September 2005 to April 2006 in Tuskegee National Forest, Macon County, Alabama. This site (32°25.57'N, 85°38.39'W) consists of a series of small ephemeral ponds and larger permanent ponds that contain tree islands ranging in size from ~1m^2 to ~1000m^2. The water table is between 10cm and 100cm below ground level on all islands, and many islands have extensive networks of passages below the soil surface that are commonly used by snakes. We excavated several burrows to determine their internal structure. Burrows consisted of one or more openings and a network of horizontal passageways that was typically located 8-15cm below the soil surface. Burrow passages were lined with a mixture of sand, tree roots, and decaying organic material and passages varied between approximately 5 cm and 25 cm in diameter.

Capture and Implantation

We recorded body temperatures of nine adult Cottonmouth snakes from 18 October 2005 to 6 April 2006. We gathered these data using implanted temperature-sensitive radio transmitters (Holohil, Ontario, Canada, model SB-2T). Transmitters allowed us to locate snakes in the field and measure body temperature at the time of location. From 15 September to 7 October of 2005 we captured nine adult Cottonmouths and brought them into the lab at Auburn University. On 10 October, we implanted a transmitter into the peritoneal cavity of each snake using the method of Reinert and Cundall (1982). We anesthetized snakes using isoflourane (Sigma) prior to surgery (mass of transmitter less than 4% of snake mass). We released snakes approximately one week after surgery.

We tracked snakes two to five times per week, between 8:00 and 18:00, from 18 October 2005 and to 6 April 2006. When we located a snake, we recorded the rate of pulses emitted by the transmitter and calculated the inter-pulse interval (IPI). IPI indicates the temperature (snake body temperature) measured by the implanted transmitter. We calculated IPI by measuring the time interval for ten pulses with a digital stopwatch and dividing this interval by ten (Hill 2004). This was repeated three times each time we located a snake, and the mean of the three IPI values was later used to calculate body temperature (see "Data

analysis"). If we disturbed an animal before recording pulse rate, the data associated with that observation were discarded. After recording pulse rate, we recorded environmental temperatures with a quick-read digital thermometer (air at 1m above ground level, water at 2.5cm below surface, and soil 12cm below surface) as close as possible to the snake's location. We recorded soil temperatures by pushing the temperature probe directly into the soil adjacent to burrows. Thus the soil temperature reported is a measure of soil temperature and not a measure of the air temperature within burrows. To avoid non-independence of temperature measurements, we recorded snake body temperature no more than once per snake in any given 24-h period.

In March-April 2006, we recaptured five snakes (males = 3, females = 2) and removed transmitters. Animals were maintained in the lab after removal surgeries until incisions closed and then released. The other four snakes that were implanted (males = 2, females = 2) could not be recaptured before the batteries in their transmitters died in April 2006.

Data Analysis

We defined over-wintering period based on the frequency of snake movements between observations. We did this because foraging Cottonmouths move frequently (Hein, unpublished data) and we were interested in the period during which snakes were not actively foraging. We inferred that snakes that were not observed moving or foraging had ceased active foraging for the over-wintering period. Between 15 November 2005 and 10 March 2006, snakes moved between burrows in only 6% of observations, as opposed to 96% before and 90% after this period. Additionally, no snakes were observed foraging during this period. Only measurements from this period were included in analyses. All snakes included in analyses were observed alive in late March-early April 2006.

To determine whether snakes conformed to air, water or soil temperatures, we compared snake body temperatures to air, soil and water temperatures using ANOVA. We used calibration curves describing the relationship between IPI and temperature provided by the manufacturer to convert IPI (ms) to body temperature (°C). We then averaged body temperatures and environmental temperatures for each snake before pooling data from all snakes. We did this because we measured each snake's body temperature and associated environmental temperatures on numerous occasions (Gotelli and Ellison 2004). Averaging within replicates (snakes) allowed us to account for autocorrelation in our repeated measurements of snake body temperatures and associated environmental temperatures. Snake body temperatures and environmental temperature measurements met normality and homoskedasticity assumptions of ANOVA. Transformation of raw temperature data did not improve normality; therefore we performed analyses using untransformed data. We compared mean snake body temperatures to mean air, water and soil temperatures using Tukey's honest significant differences method for multiple comparisons (Tukey's HSD, Crawley 2007).

To determine whether snake body temperatures differed among individuals, we used analysis of covariance (ANCOVA) to regress body temperature with local air temperature. Individual body temperature measurements from snakes met normality and

homoskedasticity assumptions of ANCOVA. We used ANCOVA because different snakes were observed on different days (which varied in environmental temperatures) and we suspected that environmental temperature would be an important covariate affecting snake body temperature. We chose air temperature as the covariate because it was the environmental variable most strongly correlated with snake body temperature. All statistical analyses were performed in the R statistical programming environment (R Development Core Team 2006).

RESULTS

Comparing Snake Temperatures to Environmental Temperatures

Transmitter measurements and associated environmental temperature readings yielded 79 body and environmental temperatures from 15 November 2005 to 10 March 2006. We excluded three snakes from analyses because we were unable to locate these individuals until the end of the over-wintering period. Additionally, One of these excluded snakes had a body temperature that was less than 0°C on two successive occasions. This individual never emerged from its hibernaculum in the spring leading us to believe that it died. We were left with 73 individual observations from the remaining six snakes (males = 4, females = 2, range = 9-13 observations per snake). Mean and standard deviation of body temperatures for each snake are displayed in table 1.

Table1. Monthly mean (standard deviation) body temperatures of Cottonmouths used in analyses.

Snake	Nov-05	Dec-05	Jan-06	Feb-06	Mar-06
1	-	23.0(-)	8.3(1.1)	11.7(3.8)	21.2(1.8)
2	-	17.3(-)	15.7(-)	17.6(1.6)	23.9(0.2)
3	-	-	22.0(-)	22.8(1.0)	24.1(1.7)
4	16.5 (-)	-	10.5(-)	11.7(1.6)	13.2(0.4)
5	28.0(1.4)	24.0(-)	21.9(3.0)	23.0(1.0)	25.4(1.8)
6	21.8 (2.6)	19.5(-)	17.5(2.1)	18.3(1.15)	20.0(0.9)

*** "-" indicates insufficient number of observations to estimate mean/std. deviation**

Overall, mean snake body temperature differed from two of the three environmental temperatures measured (ANOVA: $F = 18.19$, d.f. = 3, $p < 0.001$). Mean snake body temperature (20.0°C, 95%CI = 15.9-24.1°C) was higher than either water (15.4°C, 95%CI = 11.3-19.5°C) or soil (12.0°C, 95%CI = 7.9-16.1) temperatures but did not differ significantly from mean air (18.1°C, 95%CI = 16.4-19.8) temperature (Fig. 1). Snakes were, on average, 4.6°C warmer than water (Tukey HSD, adjusted $p = 0.003$) and 8.0°C warmer than soil temperatures (Tukey HSD, Bonferroni corrected $p < 0.001$). During the week when snakes became inactive (9-15 November 2005), mean air, water and soil temperatures were 18.1°C, 16.4°C and 8.6°C respectively. During the week when snakes were first observed above ground (10-16 March 2006), mean air water and soil temperatures were 26.7°C, 17.0°C and 14.1°C respectively.

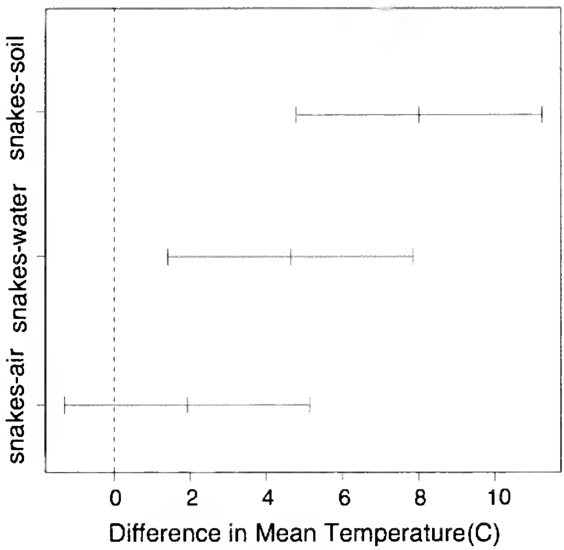

Figure 1. Tukey's HSD 95% family-wise confidence intervals for comparisons between snake body temperatures environmental temperatures. Contrasts with intervals that overlap zero are not significantly different from one another (i.e. corrected $p \geq 0.05$).

Comparing Body Temperatures Among Individuals

Body temperatures differed among the snakes over the entire over-wintering period (Fig. 2, ANCOVA: $F = 27.97$, d.f. = 4, $p < 0.001$, intercept and 95%CI of warmest and coolest snakes = 18.0°C, 13.3-22.6°C; 7.7°C, 3.1-12.4°C). The difference between intercepts for the warmest and coolest individuals was 10.3°C. The uppermost two regression lines in Fig. 2 represent body temperatures from the two females (intercept and 95%CI = 18.0°C, 13.3-22.6°C; 16.7°C, 11.8-21.6°C), and the lower three lines represent body temperatures of the three males (intercept and 95%CI = 13.3°C, 10.7-15.8°C; 13.1°C, 8.5-17.7°C; 7.7°C, 3.1-12.4°C). Body temperatures of five of the six individuals were best fitted by a common slope of 0.38 (95% CI = 0.26-0.50). One individual could not be compared using this analysis because the relationship between this snake's body temperature and air temperature differed from that displayed by all other snakes (this snake was consistently located in an inundated burrow). Consequently, we could not use ANCOVA to compare the intercept of this snake to intercepts of the other snakes. Regression analysis indicated a strong relationship between water temperature and the body temperature of this snake ($F = 13.33$, $p=0.003$, $r^2 = 0.55$, slope and 95%CI = 1.24, 0.58-1.91).

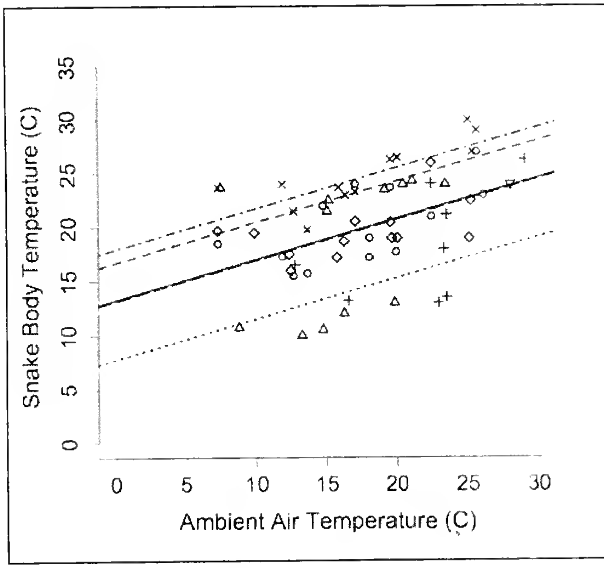

Figure 2. ANCOVA comparing snake body temperatures during over-wintering. Symbols represent measurements from different snakes. Intercepts of warmest (x, dashed line) and coolest (+, dotted line) differed by 10.3 C. Note the shallow slope of regression lines (0.38, 95%CI = 0.26-0.50).

DISCUSSION

Several authors have suggested that snakes engage in thermoregulatory behavior or select hibernacula during the winter (Prior and Weatherhead 1996, Harvey and Weatherhead 2006, Schuett et al. 2006). This is not surprising given that environmental temperatures drop to lethal levels during winter in many areas (Shine and Mason 2004). The winter basking behavior observed in some species is an example of winter thermoregulation (Schuett et al. 2006). However, we did not observe any snakes above ground during the over-wintering period, which led us to believe that snakes remained within burrows. The Cottonmouth population at our site is known to number at least in the hundreds (C. Guyer unpublished data), and many snakes are typically observed moving and basking above ground during late spring, summer and early fall. Because we did not observe any individual above ground during the over-wintering period, we do not believe that snakes in our population engaged in behavioral thermoregulation outside of their burrows during winter. Rather, Cottonmouths in our study population engaged in within-burrow thermoregulatory behaviors or selected burrows that offered particularly warm winter temperatures.

We acknowledge that any conclusions about over-wintering behavior drawn from this study must be tentative due to the small number of snakes used. However, our study provides a window into over-wintering thermal biology of Cottonmouths, an aspect of their life history that has not been previously described. Although snakes were below ground during all telemetry observations, snake body temperatures were warmer than soil or water

temperatures. This result is surprising; since snakes were located in burrows in the soil, we expected their body temperatures to closely reflect soil temperatures. Additionally, snake body temperatures were relatively insensitive to fluctuations in air, water and soil temperatures. The shallow slope of regression lines of snake body temperature on air temperature suggest that snakes were buffered against fluctuations in air temperatures (regressions between body temperatures of these snakes and soil and water temperatures yielded similarly shallow slopes of 0.56, and 0.57 respectively).

Snake body temperatures could have differed from the environmental temperatures that we measured for several reasons. While Cottonmouths are not known to engage in thermogenic behavior such as shivering, some snake species do generate heat by rapidly contracting muscles (e.g. Pythons, Harlow and Grigg 1984). It is also possible that snakes were buffered from extreme temperatures by over-wintering in communal burrows. Although none of the animals that we radio-tracked were loeated in burrows with one another, it is possible that our study animals shared burrows with other snakes. Finally, the burrows used by our study individuals may have been warmer than the surrounding soil and water. When we excavated burrows in April 2006, we found abundant organic material within burrows. Decomposing organic material may have created localized hot spots that were warmer than the surrounding soil. Clearly, these data emphasize the need for a more comprehensive understanding of how snakes in this and other populations regulate their body temperatures during winter.

A second important observation gleaned from our study is that mean body temperatures of snakes differed from one another. Differenees in over-wintering body temperatures may lead to important differences in the eosts and consequences of over-wintering experienced by different individuals. McCue and Lillywhite (2002) described the relationship between temperature and metabolic rates of Cottonmouths. Following their equations, we estimated an approximately 4.5 fold difference in over-wintering energy consumption between the coolest and warmest snakes (15kJ and 69kJ respectively) in our study. These differences may represent non-trivial differences in the energetic costs of over-wintering among individuals. Blem (1997) and Wharton (1969) identified lipid reserves as an important factor affeeting survival of Cottonmouths through over-wintering periods. Blem (1997) suggested that animals might die during warm winters as a result of exhausting lipid reserves. Because body temperature is positively eorrelated with metabolic rate and consequently, energy consumption, staying warm during the winter may carry a significant energetic cost. Conversely, staying too cold may also carry significant costs. One of the snakes in our study exhibited body temperatures below 0°C on two occasions in February. We believe this individual died from exposure to lethal low temperatures.

These data represent the first report of Cottonmouth thermal behavior during the winter. The potential eosts and benefits of high and low body temperatures during over-wintering and inter-individual variation in over-wintering body temperatures have been under-appreciated in past work. Though limited by the small number of individuals included, our study highlights these important aspects of thermal biology and draws attention to the need for future studies of over-wintering thermoregulation in ectotherms. More complete characterization of over-wintering thermal behavior in this and other species may help to determine the importance of winter thermoregulation to the survival and fitness of temperate reptiles.

ACKNOWLEDGEMENTS

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PRELIMINARY INVESTIGATIONS AT THE SKELETON MOUNTAIN SITE, 1CA157, CALHOUN COUNTY, ALABAMA

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ABSTRACT

In 2007, the Jacksonville State University Archaeological Resource Laboratory and several volunteers began the investigation of a stone feature on the crest of Skeleton Mountain overlooking the former Fort McClellan in Calhoun County, Alabama. JSU-ARL researchers believe prehistoric Woodland and/or Mississippian Indian populations constructed this structure between 2500 to 800 years ago as part of their ceremonial/ mortuary rituals.

INTRODUCTION

In March 2007, Jacksonville State University Archaeological Resource Laboratory (JSU-ARL) staff and volunteers began the preliminary mapping and photographing of the stone snake effigy. Approximately three days were spent clearing, mapping, and photographing the stone structure and other stone features within the immediate vicinity.

In 1976, University of Alabama in Birmingham (UAB) staff archaeologists conducted the initial investigation of this stone feature and recorded it as site 1Ca157. Several recent push piles created by earth-moving equipment along the northern portion of the site were also noted (McEachern *et al.*, 1980).

In the 1990s, as part of a Phase I Archaeological Survey of Fort McClellan, Jacksonville State University (JSU) archaeologists revisited the site and noted that the stone feature was constructed of loose, angular quartzite and limestone cobbles in a raised walkway-like structure of homogeneous height and width. This feature was laid in a serpentine fashion along the edge of the steep, western slope of Skeleton Mountain (Holstein *et al.*, 1995) (Fig. 1).

During 2004, Creek and Seminole tribal leaders, local officials, and JSU archaeologists visited the site. Native American representatives were in agreement as to the ceremonial and spiritual sacredness of the site, that it needed immediate protection, and that plans should be made to map and photograph the structure.

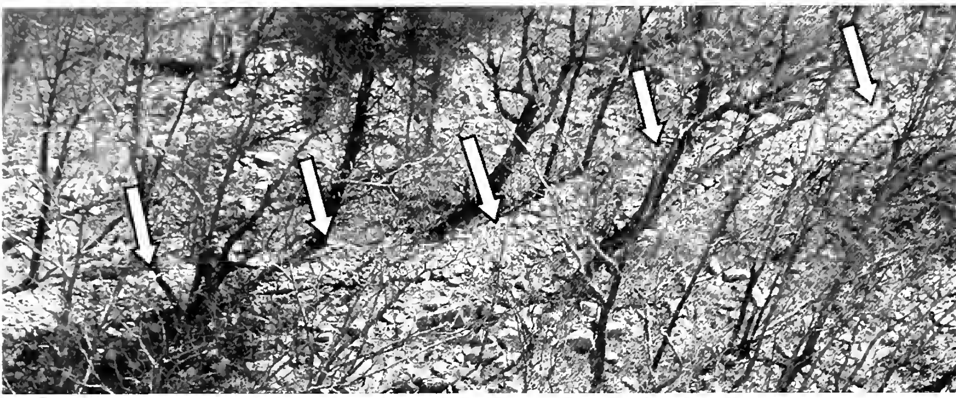

Figure 1. Aerial view of the Skeleton Mountain Snake Effigy. Photo courtesy of Steve Miller.

Site 1Ca157, is positioned along the edge of the steep western slope of Skeleton Mountain in southeastern Calhoun County, Alabama. Skeleton Mountain, in turn, is a portion of the southern end of Choccolocco Mountain, the first major northeast /southwest ridge of the Ridge and Valley Physiographic Province. The site lies approximately 518 m (1700 ft) above mean sea level. Access to the site via United States Fish and Wildlife Longleaf Pine Preserve roads is difficult, requiring, in most cases, four-wheel-drive vehicles. The present vegetation is mainly longleaf and southern pines mingled with scattered hardwoods. The soil is shallow with bedrock frequently exposed across the land surface. The ridgeline is littered with moss and lichen-covered cobbles and boulders. No surface water is located on or near the site, and surface erosion appears to be minimal.

FIELD METHODS

The fieldwork was carried out over a two-day period on March 5 and 6, 2007. The Field Director for the project was Dr. Harry O. Holstein. The field crew consisted of JSU-ARL staff Jacob Kohute, Sean Williamon, Tim Hobgood, and Ed Hill. Tim Moon of the Anniston Museum of Natural History, the Reverend Monty Clendenin, Gary Lawson, and Richard Haynie volunteered for the project. Robert Perry and Matthew Grunewald provided and operated the total station for mapping the site. Ron Ellington, of Ellington Enterprises, provided assistance with unexploded ordnance (UXO) avoidance at the site. The initial objective was to determine the extent of the site so that it could be mapped and photographed, and to assess the damage from previous bulldozer activity.

To accomplish this objective, a limited surface pedestrian survey was undertaken. It was hoped that the surveyors would be able to locate additional stone features that may be related to the snake effigy. Due to UXO constraints, the steep slopes located along the western edge of the snake effigy were designated off limits. Eight members of the

field crew were lined up along the northern end of the effigy (near bulldozer push piles) and were spaced at 5 m (16 ft) intervals. Walking parallel transects southward along the eastern slope, adjacent to the serpentine feature, surveyors continued until they reached a noticeable decrease of the ridgeline approximately 30 m (98 ft) beyond the point where it was believed the head of the snake was positioned. At that point, three of the surveyors moved to their right and began 5 m (16 ft) interval transects north to cover the area that was located in front of the head. The steep western slope was visually inspected from the edge of the effigy and ridgeline. This resulted in locating old bulldozer cuts through the surface of the natural boulder-strewn slope associated with the northern portion of the site. One man-made, loosely stacked, horseshoe-shaped, low wall feature was identified a few meters east and middle of the serpentine structure.

The second objective was to prepare the site for photographing and mapping. Utilizing leaf blowers, rakes, and tree limb loppers, crewmembers began work in the northern portion of the site and systematically removed all vegetation and leaf litter from the surface of the stone effigy as well as the surrounding ground surfaces. Additional clearing also was conducted upon the stone feature and throughout the northern push pile area and possible tail section feature. Once site preparation work was complete, mapping and photographing commenced.

Global positioning system points were generated by using a Topcon GTS 230W™ total station. A temporary site datum was placed adjacent to the structure. All points were shot from this datum to improve horizontal and vertical accuracy across the entire site. These points were used to create the plan view map of the snake effigy and associated stone features (Fig. 2).

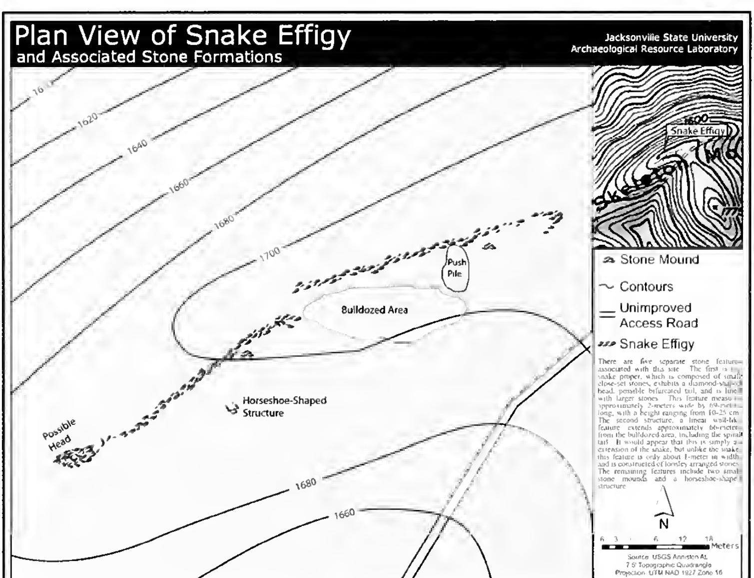

Figure 2. Plan view of site 1Ca157, Skeleton Mountain Snake Effigy.

RESULTS AND OBSERVATIONS

Upon completion of the 2007 investigation, it was determined that site 1Ca157 was more complicated than first thought. For example, several stone features straddle the edge of Skeleton Mountain along the 518 m contour line overlooking the former Fort McClellan to the west and a panoramic view of Cheaha Mountain to the south (Fig. 3).

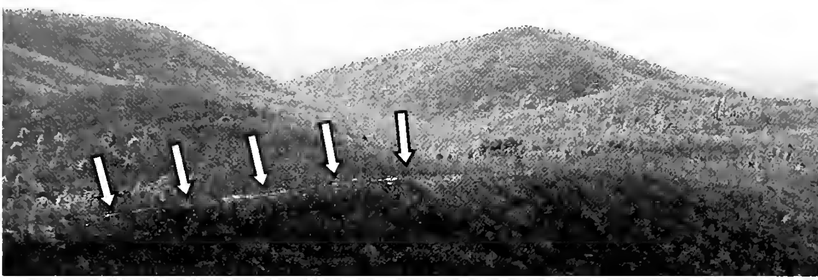

Figure 3. Snake Effigy, 1Ca157, located along ridgeline in foreground of photograph.

Also, beginning in the southwestern corner, researchers located a triangular pile of stones believed to represent the serpent's head. This pile measures approximately 1 m at the base and 1.5 m in height (Fig. 4).

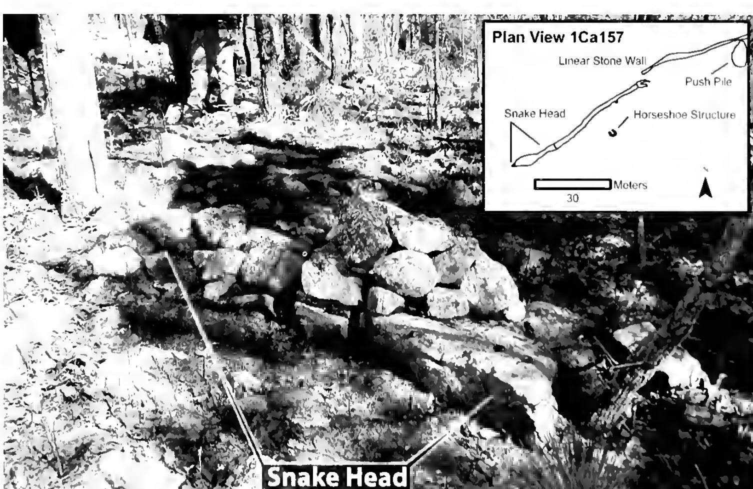

Figure 4. Portion of the effigy structure believed to be the snake's head.

Directly behind the stone pile "head" (northeast) lies a 18 m zone of loosely scattered surface boulders similar to the stones used in the tightly constructed main body of the serpentine structure, but without any apparent pattern. If the stone pile is the head of the snake effigy, then the scattered surface boulders have either been disturbed after their initial deposition or, maybe, an area where the serpentine wall was never completed. Although similar loose stone surface boulders are located across the entire ridgeline adjacent to the serpentine feature, this area between the head and the rest of the body does appear to be more dense. The result is the appearance of trying to fill in the natural surface boulders with more rocks in order to create the same stone pavement and connect the tightly-packed stone segment to the stone pile head.

Beyond this scattered surface stone segment and continuing toward the northeast, the tightly-packed pavement begins (Fig. 5). This stone pavement gently curves back and forth along the ridgeline in a southwesterly direction for approximately 49 m terminating adjacent to a recently bulldozed area. This stone segment is relatively homogeneous in size and construction. The pavement is approximately 2 m in width for its entire length and 0.25 m in height. It is apparent that these dimensions were purposely maintained throughout this segment. All of the stones used in the construction are available in the immediate vicinity (Fig. 5). In addition, researchers observed that several of the quartz cobbles appeared to have been intentionally shaped (knapped) so that they would fit into the relatively level surface of the pavement.

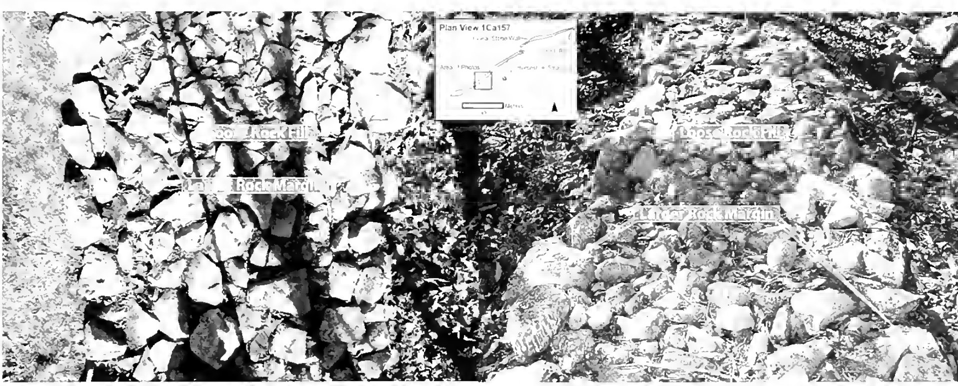

Figure 5. Dense concentration of cobbles forming walkway.

What is noteworthy, the stones placed along both edges of the pavement tend to be consistently larger than most of the interior stones. This suggests the builders first laid two parallel rows of large stones to maintain the homogeneous shape of the structure as it was constructed across the ridgetop.

Two other man-made structures were observed in the vicinity of the serpentine pavement. The first man-made structure is a horseshoe-shaped 0.5 m high stone structure that lies on the southern slope of the ridge approximately 10 m south of the middle of the pavement. The three sides of the horseshoe-shaped structure are approximately 2 m in

length with the mouth of the horseshoe facing northwest towards the serpentine pavement (see Fig. 2). It should also be noted that looking southeast from the horseshoe-shaped structure through a gap in the ridge east of Skeleton Mountain, Mount Cheaha, Alabama's highest mountain, is clearly in view.

The second man-made structure is a linear, low stone wall immediately north of the possible tail of the serpentine structure, a separate linear stone wall runs for 65 m in the same southwesterly to northeasterly direction along the very edge of the steep western slope of Skeleton Mountain. It crosses closely behind and past the disturbed bulldozed area and the associated large push pile of boulders, terminating at what appears to be a spiral array made of single stones lying directly upon the surface. This stone wall averages between 1 to 1.5 m in width and less than 1m in height.

Two push piles of loose stones are located just east and south of the spiral feature. It is possible that the smaller stone (less than 1m high and 1m in diameter) may be of aboriginal origin. However, due to the apparent disturbances surrounding this structure, it is more likely that it is of recent origin. Nevertheless, a nearby larger rectangular stone pile (2 m high and 10 m in length by 3 m in width) is clearly the result of twentieth-century mechanized activity. Bulldozer tracks through the natural boulder-strewn surface leading to the mound's base are evident along three sides. There has been a large amount of recent bulldozer activity within this northern area but to the south, in the vicinity of the stone pavement, no recent disturbance was apparent.

Since the linear stone wall is located directly on the edge of the ridge crest and directly behind the bulldozed area, it is unlikely this feature is the result of recent earth-moving activity. However, in most areas adjacent to this linear feature, there is no evidence of machine tracks or push piles. Also, the wall is constructed of loose stone quartz cobbles similar to the serpentine pavement and does not contain any quartz pebbles or intermixed soil typical of the recent push piles. This wall appears to be comparable to the linear stone wall features found at other stone structure sites throughout northeast Alabama, thus lending credence to the possibility that it may be of prehistoric origin.

To summarize or observations, it is apparent that the primary serpentine pavement, required planning and skill to maintain its consistent shape and size of the structure for the distance of 40 m across the stony ridgetop. However, the overall structure may be incomplete as the head appears detached from the serpentine "body" by some 18 m. The adjacent horseshoe-shaped stone feature appears to be of aboriginal construction and is probably associated with the serpentine pavement (Fig. 6). The 65 m stone wall likewise appears to be of aboriginal construction and terminates on the northern end of the site into a spiral single-stone "tail" section. Disturbances from bulldozer activity are apparent throughout the northeastern portion of the site and may include a small area of the northern end of the stone feature. For the most part, the central and southern portions of the stone structure are undisturbed by recent earth-moving activities.

Fig. 6. Horseshoe-shaped structure associated with the snake effigy.

SITE DISCUSSION

The effigy is actually a low, loose rock wall/pavement running along the western edge of the summit of Skeleton Mountain (Fig. 7). Although 1Ca157 is referred to as a snake effigy, the individuals who constructed the serpentine wall may or may not have intended the structure to mimic a snake/serpent. As with the hundreds of other stone wall and mound sites scattered throughout the eastern United States, two questions are frequently posed: Who built these structures and why?

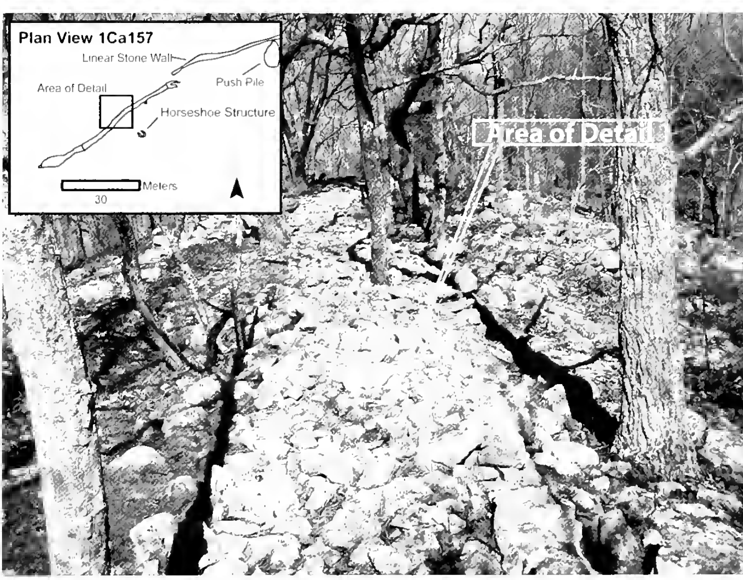

Figure 7. View along snake effigy, facing northeast.

Many non-archaeologists, as well as professional archaeologists alike, believe stone piles are the result of early farmers clearing land for agricultural pursuits or settlers/ farmers stockpiling rocks for use as foundations, support pilings, buildings, fireplaces, or chimneys. Also, walls are typically explained as agricultural terraces since many of these structures run parallel with slopes of ridges and mountains. Another common explanation for the stone walls is that they are property markers.

However, several archaeologists believe that in many cases the stone mounds and walls are the result of prehistoric Native American cultural activities. In particular, stone piles and walls appear to have played some type of role in Native American religion and/or socio-political activities.

In considering who may have built the snake effigy, nineteenth and twentieth-century settlers/farmers seem unlikely candidates. Granted, as they first moved into the fertile valleys of northern Alabama, rock piles and stone walls were created. As fields were cleared, roads and homes were constructed; rocks were moved and piled up. Rock walls were used to demarcate roads, gardens, and property lines. Any former road that had been paralleled by stone walls would leave several distinctive footprints on the land, and if the road was not a dirt road, there would be evidence of the roadbed in the form of gravel, chert, sand, or other crushed stones. Site 1Ca157, however, is definitely not associated with previous roads. No roadbed stones were observed. Surface boulders and cobbles lie on both sides of the pavement and all of the stones are laid directly on the ground surface creating a dense concentration of cobbles and boulders in a serpentine pattern.

The snake effigy is a 59.7 m serpentine lineal wall/pavement stretching along the stone-rubble strewn surface of Skeleton Mountain in an area that would be nearly impossible to cultivate. Most importantly, the shallow rocky soil on which the snake effigy is situated is unsuitable for growing row crops and would be nearly impossible to plow with nineteenth or early twentieth-century farming technology (Harlin and Perry, 1961).

It is frequently suggested that stone walls are constructed along steeper slopes for agricultural terraces, or in some cases erosion control. It is true that in northern Alabama, during the mid-twentieth century, agricultural terracing was a widespread practice. Terraces are simply cut in the natural slopes and graded. By the late nineteenth and early twentieth centuries, agricultural fields were expanding from the valley floor onto steeper slopes. Accessibility for horse or mule plowing would determine how far up the slopes from the base of Skeleton Mountain fields would extend. The much steeper slopes of 15 percent or greater would not be desirable or even possible to cultivate by traditional methods. In addition, the low population density of the area during the nineteenth century, and the lack of twentieth-century technology, would have severely limited the need or desire to venture onto the steeper, stony ridge slopes and mountain tops when the broad fertile valley below provided plenty of tillable land.

Erosion control, likewise, can be ruled out. The serpentine structure is situated on the level crest of Skeleton Mountain, not on the steep slopes of the mountain where one would expect to find erosion control walls.

Cultural activities that may have occurred in the vicinity of the site during the nineteenth and twentieth centuries would have, in all likelihood, been hunting, recreation, military exercises, and/or timber harvesting. Hunters and recreational users, who have

traversed this area since the early nineteenth century and continue to this day, would have no reason to take the time and effort to construct this large serpentine structure.

With the creation of the Fort McClellan Military Reservation in the 1940s, the land in the vicinity of the site received some negative impact. During the 1940s, the slopes of Skeleton Mountain were used for military target practice. As a result, unexploded ordnance are currently scattered along the steep slope directly below the snake effigy (Ellington, personal communication, 2007). At the time UAB archaeologists recorded the site in the 1970s, they noted considerable bulldozer damage in the form of push piles in the northern portion. In addition, the military more than likely bulldozed an access road that parallels the snake effigy and runs across the summit of Skeleton Mountain 20 m east of the stone structure.

It is well documented that the steeper hillsides of the mountains and ridges of Calhoun County were cut for timber for use in the expanding villages and towns below. In the vicinity of the snake effigy, the forest is dominated by secondary growth southern and longleaf pines and hardwoods. Since timber harvesting is still a commercial activity in Calhoun County, large sections of ridges and mountain slopes are presently being clear cut. These twentieth-century loggers do not bother to clear rock from the areas they cut; they are simply interested in harvesting the trees.

Native Americans are the likely candidates for the effigy construction. Many Native Americans consider these types of structures to be part of their animatistic, spiritual/religious beliefs. The site may represent a sacred stone memorial/marker to commemorate the earth's natural wonders, deceased loved ones, or some other event that was considered special to the people who constructed them. The serpent motif is quite prevalent throughout Native American history. Snakes are frequently depicted upon Indian ceramics, shell, and other artifacts. The significance of the serpent design is discussed in detail in a report titled *The Moundville Expeditions of Clarence Bloomfield Moore* (Knight, 1996). Charles Faulkner discusses prehistoric and early historic serpent cave glyphs recorded in Tennessee. At Mud Glyph Cave in eastern Tennessee, a horned serpent glyph had associated radiocarbon dates that ranged from A.D. 465 to A.D. 1760 (Faulkner, 1997).

Finally, one of the strongest reasons for believing the Skeleton Mountain Snake Effigy site, 1Ca157, and other stone structures are an integral part of the Native American belief system has recently been expressed in a resolution introduced by the United South and Eastern Tribes (USET) at the Impact Week Meeting held in February of 2007 in Arlington, Virginia. USET is comprised of 24 federally recognized tribes. Resolution No. 2007:37 states in part "whereas, whether these stone structures are massive or small, stacked, stone rows, or effigies, these prayers in stone are often mistaken by archaeologists and State Historic Preservation Officers (SHPO) as efforts of farmers clearing stones for agricultural or wall building purposes; and archaeologist and SHPOs, categorically thereafter, dismiss these structures as non-Indian and insignificant, permitting them to be the subject of sacrilege of archaeological dissection and later destruction during development projects." The resolution goes on to express the importance of "protection of these ceremonial stone landscapes and their structures within USET ancestral territories."

INVESTIGATIONS OF SIMILIAR STONE STRUCTURES THROUGHOUT THE EASTERN UNITED STATES

Numerous similar stone wall structures have been recorded throughout the Southeast. Philip E. Smith, in his classic 1962 study *Aboriginal Stone Constructions in the Southern Piedmont*, describes numerous stone wall and mound sites. Some of the closest to the Skeleton Mountain snake effigy include two stone walls and a ditch at DeSoto Falls in DeKalb County. First described in 1823 by a missionary in Chattanooga, the walls enclosed a steep promontory overlooking DeSoto Falls. The arched outer wall made of loose sandstone slabs was 183 m long, and the parallel inner wall was 152 m long with a four-foot wide by one- to two-foot deep ditch built in front of it. In 1823 the walls were four feet in height (Smith, 1962).

Approximately 50 miles northeast of DeSoto Falls, on Lookout Mountain, lay several mounds and rambling walls. Smith (1962) describes the loose stone walls and 29 stone circles/rings or Confederate rifle pits at the Chattanooga-Chickamauga National Military Park overlooking Moccasin Bend of the Tennessee River. These stone features were first reported by Confederate Brigadier General E. C. Walthall in 1863. The walls and circles are situated on the steep eastern slope of Lookout Mountain. The largest wall "is constructed of loose rough stone piled to an average of three feet in height, and is a somewhat rambling affair running 126.5 m in length. All three sections of the walls appear to tie into a series of natural stone outcrops" (Smith, 1962).

Another interesting site described in some detail by Smith (1962) is the Fort Mountain State Park site in northwest Georgia. This site is situated on a saddle near the summit of Fort Mountain and consists of loose piled native stone. The wall's width varies from 1.5 to 5 m; the height ranges from 1 to 3 m, and the length is 270 m. There are several gaps in the wall, which meanders and zigzags along the saddle. The wall was first documented in 1849, and is described in great detail in 1893 by Robert Shackleton in the *American Antiquarian and Oriental Journal*. Shackleton stated that a few arrowheads were found inside the wall (Smith, 1962).

Smith (1962) describes a 191 m serpentine stone wall running just below the eastern crest of Sand Mountain in Catoosa County, Georgia. This wall lies in a similar topographic setting to the Skeleton Mountain structure. The main wall runs horizontally along Sand Mountain's slope, terminating at the steep bluff of the mountain. There are five additional shorter sections that appear to be an extension of the main wall. Also, another short wall runs directly down the steep bluff through a boulder-strewn portion of the mountain. Overlooking these walls on the peak of Sand Mountain are five conical stone mounds (Smith, 1962).

Smith (1962) lists 12 Kentucky stone wall sites, which were all recorded in 1932 by William S. Webb (Webb and Funkhouser, 1932, as cited by Smith, 1962). Two stone wall sites were listed in Indiana, the earliest being recorded in 1891. Smith (1962) listed six stone wall sites in Ohio, with one of them having stone mounds nearby. Most of these Ohio Valley sites were first described as early as 1848 by Squire and Davis (Smith, 1962).

The Fort Mountain State Park wall is similar to another state park site near Manchester, Tennessee, the Old Stone Fort. This site was first recorded and mapped by Squire and Davis in 1848. The stone and earthen rubble walls enclose a 40-acre hillcrest that overlooks the forks and falls of the Little and Big Duck Rivers. The longest continuous stretch of the wall runs for over 2000 feet. The walls have been radiocarbon dated from AD 230 to AD 430, during the Middle Woodland period. Two earthen conical mounds lie just outside one of the gaps or "gateways" to the wall (Faulkner, 1969).

Finally, in 1883, Charles Whittlesay described a loose stone "fortification" encircling the rocky summit atop Ladd Mountain in Bartow County, just west of Cartersville, Georgia. This irregular oval wall had six openings of 10 to 60 feet in width (Wauchope, 1966).

The majority of stone structure sites were described by or before the 1890s in states that had been settled by Americans for only 60 years or less. Native Americans in Georgia, Tennessee, and Alabama still controlled most of the native lands into the 1830s. Most of these stone structure sites are situated in places considered, at best, marginal for farming practices and, at this early date, unlikely to have been timbered or farmed by early settlers.

Archaeologists have conducted extensive research on stone structures in northeast Alabama, Tennessee, and northwest Georgia. In 1985, David Chase recorded 15 stone mound sites in the Talladega National Forest. At site 1Cy32, located near the summit of Flat Top Ridge, three stone mounds received partial excavation. One mound contained animal bone, a Late Woodland Hamilton arrow point, and a sherd of grog-tempered pottery. The second yielded a single Middle to Late Woodland Greenville hafted biface, and the third yielded no artifacts. Chase also observed an 82 m long, 3 to 6 foot wide, and 1 to 2 foot high stone wall at the site (Chase, 1985). Another stone mound complex reported by Chase in 1985 was Penitentiary Mountain in Shelby County. This stone mound complex contains triangular and rectangular stone walls enclosing 13 stone mounds and covers over three acres (Chase, 1985).

In 1985, Holstein and Little recorded several stone mound sites in northeast Alabama. One site, the Brock Mountain site, consisted of a low stone wall that enclosed a single stone mound on a high ridgetop. The stone wall measures approximately 74 m in circumference and varies from 9 cm to 52 cm high (Holstein and Little, 1985).

The JSU-ARL has been surveying portions of the rugged Talladega National Forest since 2004, and they too, have recorded 53 stone mounds and walls sites. Nineteen of these stone mound sites had associated walls (Noel *et al.*, 2004a; Windham *et al.*, 2005; Ridley, 2006, 2007, 2008).

Surveys conducted by the JSU-ARL during 1982, 1995, 1999, 2007, and 2008 reported 29 stone mound sites located on the Pelham Range portion of Fort McClellan, Calhoun County, Alabama. Fourteen of these sites also had stone walls in association with the mounds (Holstein *et al.*, 1995; Ridley, 2007, 2008).

An additional 22 stone mound sites were recorded on portions of Pelham Range in 2005 and 2006. Four of these sites had stone walls in association with the stone mounds (AMEC, 2006).

During 1993 and 1994, JSU-ARL staff conducted excavations at 3 stone mound sites (1Ca139, 1Ca470, and 1Ca550) previously recorded by the JSU-ARL that were located on Pelham Range. A total of eight stone mounds were partially excavated. Four mounds yielded Native American artifacts from submound context.

Site 1Ca139 consisted of more than 23 stone mounds and four linear stone walls situated along a westward slope overlooking Cane Creek. Four mounds were excavated yielding a single quartzite flake and a Woodland-like ovate quartz biface recovered from Mound 21 (Holstein *et al.*, 1995).

Site 1Ca470 consists of a solitary stone mound situated on a ridge crest above a tributary of Cane Creek. The submound excavation yielded 25 specimens of chert debitage, one chert scraper, and one Woodland grit-tempered check-stamped pottery sherd (Holstein *et al.*, 1995).

Site 1Ca550 consists of 56 stone mounds situated on a ridgetop located north of Cane Creek. Three mounds were selected for excavation. Thirteen pieces of chert debitage were recovered from Mound 7. No artifacts were found in Mound 16, but Mound 51 yielded one fragment of quartzite debitage, one piece of chert debitage, and two rifle shell casings in the upper 20 cm of the submound matrix (Holstein *et al.*, 1995).

JSU-ARL researchers concluded, based on the Pelham Range stone mound investigation and other stone mound studies in the region, that the widespread stoneworks phenomena occurring in upland environments of northeast Alabama may best be explained as manifestations of Woodland ceremonial systems (Holstein *et al.*, 1995).

During 2000, JSU-ARL archaeologists investigated stone mound and wall site 1Ca142, located along Cane Creek on Fort McClellan. The site consisted of 17 conical sandstone mounds, one "F"-shaped stone wall and two lineal stone walls paralleling portions of Cane Creek. Four of the 17 mounds were partially excavated. Other than rifle shell casings, no artifacts or submound features were observed (Little and Smith, 2000).

Investigations at site 9Un367 on United States Forest Service (USFS) property in northern Georgia has utilized new dating techniques to support prehistoric Native American populations as likely candidates for stone mound and wall construction. New South Associates of Stone Mountain, Georgia mapped and partially excavated a stone wall and stone pile at Track Rock Gap. Nearly 40 lineal stone walls and 50 stone piles straddle the slope. Within the gap lies 9Un361, a Native American petroglyph site and a natural underground steam vent. A portion of one stone pile and one wall were excavated. Upon removing a quarter of the stones from the rock pile, investigators uncovered a semicircle of rocks enclosing a dark soil fill. As the researchers screened the fill dirt, a ceramic pipe fragment, a Woodland fabric-impressed potsherd, two plain sherds, and quartz flakes were recovered. Two groundstone artifacts, a pitted cobble, and a metate were also recovered from the surrounding stone mounds. Since it was strongly believed this represented a Native American mortuary area, excavation was immediately halted (Loubser, 2002).

Only one quartz flake was recovered from the partial wall excavation at site 9Un361. However, six oxidized carbon ratio (OCR) soil samples were obtained. Five samples were recovered from within the stone wall and one sample taken from directly

beneath it. The three dates from the soil within the stone matrix immediately above the original ground surface (Layer 2) ranged from AD 3 to AD 1075 while the soil directly underneath the stones was dated to AD 1101, suggesting the mound was constructed during the Late Woodland to early Mississippian time period. The researchers concluded that the mound was constructed during the Woodland time period and that Mississippian populations built the walls shortly thereafter. They also pondered a possible link between the petroglyphs, natural steam vent, and stone mounds and walls at 9Un367 (Loubser, 2002). Based on similar stone mound complex data from other stone wall sites, JSU-ARL researchers agree there is a relationship and also include the Track Rock Gap into the mix. The following descriptions of additional stone structure sites support this assumption.

Two other northeast Alabama stone structure sites are of interest to this study: the Shelton Stone Mound Complex and the Morton Hill Stone Wall Complex. In 2006, the JSU-ARL conducted investigations at the Shelton Stone Mound Complex, 1Ca637, which straddles the eastern slope of Choccolocco Mountain overlooking Whites Gap in eastern Calhoun County. The majority of the stone mound complex is located on personal property, with a portion extending into adjacent USFS property. The site, at present, consists of 79 stone conical mounds, one horseshoe-shaped mound, 31 lineal stone walls, one serpent-like stone wall, one Z-shaped stone wall with natural boulder feature, one V-shaped stone wall, and one oval boulder configuration. The entire stone structure complex straddles a natural amphitheater halfway up Whites Gap on Choccolocco Mountain. Mountain gaps, as well as other natural landscape features, in all likelihood would have been considered sacred areas to Native Americans. Further to the south of Shelton Stone Mound Complex, the Morton Hill Stone Wall Complex overlooks Bains Gap of Choccolocco Mountain (Holstein, 2007).

The Morton Hill Stone Wall Complex, 1Ca671, is situated on the crest of Choccolocco Mountain, just north of the Skeleton Mountain snake effigy. In 2006, JSU archaeologists were informed of stone walls running along the steep summit of Morton Hill just south of Bains Gap. The walls range between 0.5 m to 1 m in height and width. The length of the walls is the most significant factor about this site. JSU-ARL researchers estimate there are, at a minimum, one to two miles of walls crisscrossing the summit. Along the steep (25%) eastern slope, a series of parallel walls runs along the contour lines of a natural amphitheater-like basin. These walls overlook two springheads near the base of the basin. One springhead is presently dry, and the other is flowing. A small, low (less than 50 cm) stone wall runs perpendicular to the slope connecting the higher dry spring to the lower wet one.

Another wet weather springhead is situated on the summit at the northern end of the site. This springhead is situated on a bench-like formation that comprises the most level portion of the summit. Several walls parallel the western edge of this flat area, and one stone wall curves sharply from the top edge down over the steep western slope. Another wall runs for approximately 61 m straight along the level top then turns 90 degrees eastward down a gentle slope and then terminating 9 m from the springhead pool. Six meters from the pool, a short, low wall runs north/south paralleling the pool and springhead. Several of the walls in the western flat area contain rock mounds or bulges within the stone walls and/or at the ends of the walls.

Finally, a few other general observations of the Morton Hill Stone Wall Complex include the fact that many walls either terminate at, or incorporate, natural boulder outcrops. On the summit directly above the natural amphitheater parallel wall, three lineal parallel walls run east/west across the top of the summit while another wall of the southern edge of the amphitheater curves sharply from the eastern crest edge and winds its way up a gentle boulder/cobble strewn knoll terminating at the second highest point of the Morton Hill summit. The entire site is estimated to cover over 10 acres of the north and south slope of Morton Hill.

The Stone Serpent Mound, 15Bd6, of Boyd County, Kentucky is in many ways similar to the Skeleton Mountain snake effigy. The Stone Serpent Mound is located along the edge of a ridgetop overlooking a steep side slope, which in turn overlooks the Big Sandy River. Both effigies have meandering low walls that are constructed from locally available sandstone (15Bd6) or limestone (1Ca157) cobbles with little soil matrix and are less than a meter in height. The Boyd County snake is longer at 191 m and wider (2 to 11 m) than the Skeleton Mountain snake. In 1988, the Boyd County snake effigy was mapped, photographed, and partially excavated. No cultural materials were recovered, but based on comparative regional stone structure data, the researchers believed the snake had been constructed by prehistoric Woodland populations (Sanders, 1991).

Several other serpentine stone walls have been documented throughout the Eastern United States. In Warren County, Ohio, two serpent effigy mounds were recorded along the floodplain of the Little Miami River: Kern Effigy I (33Wa372) and Kern Effigy II (33Wa373). No artifacts were reeovered from either structure. Kern Effigy 1 was approximately 27 m long by 1.5 m wide, and Kern Effigy II was approximately 47 m long by 1.8 m wide. Two radiocarbon dates were obtained from subsurface testing of Kern Effigy 1 of AD 1185 and AD 1420, placing them both in the Late Woodland (Fort Ancient) time period.

CONCLUSIONS

In 2007, JSU staff and volunteers began the investigation of the Skeleton Mountain Snake Effigy, 1Ca157. This serpentine stone pavement and several other associated stone features were mapped in detail and photographed. It was apparent that the stone structures required a considerable amount of labor to construct and that the serpentine pathway was well planned in order to maintain its relatively uniform size. It also appears the effigy may not have been totally finished by its builders, since the probable "head" is somewhat detached from the serpentine "body". Based on comparable data from other prehistoric stone wall sites in the Southeast, and ethnographic data documenting the importance of the serpent symbolism in Native American art and mythology, ARL researchers believe prehistoric peoples constructed this stone structure sometime during the Woodland or early Mississippian time periods. Likewise, they believe a small horseshoe-shaped structure, a linear stone wall, and the detached head were constructed by the same prehistoric populations. Also noted was a considerable amount of recent historic disturbance in the site's northern section.

Additional investigative steps should be undertaken to better understand the purpose and the time period of construction for site 1Ca157. A more extensive Phase I survey should be conducted in the vicinity of the site. Adjacent ridgetops should also be surveyed for stone features. It is possible additional stone mound/wall sites might emerge from nearby ridgetops possessing similar terrain. The next step would include limited subsurface testing on, and adjacent to, the serpentine pathway, horseshoe-shaped structure, and linear wall features. These excavations would be designed to recover any archaeological data that would aid in identifying who constructed the structures, why, and when. OCR soil samples would be acquired from the interface at the base of the structures and the underlying surface. This dating method, coupled with any radiocarbon dates acquired, would provide the temporal answer as to when these structures were built.

ACKNOWLEDGEMENTS

This research would not have been possible without the financial help from the Joint Powers Authority of McClellan, Alabama and several other individuals. The following Calhoun County residents volunteered their time and effort in initial fieldwork of this project: the Reverend Monty Clendenin, Richard Haynie, Gary Lawson, and Tim Moon. Valerie Glesner assisted in organizing, editing, and typing the initial manuscript, and Sean Williamon assisted with the photographs and maps. Also, the U. S. Fish and Wildlife Service Longleaf Pine Preserve manager, Steve Miller, graciously allowed the field crews access to the site and provided aerial photographs of the Snake Effigy. Finally, much thanks to Robert Perry and Matthew Grunewald who provided and operated the total station for mapping the site.

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In memory of Dr. William Jordan Barrett
Scientist, Father, Friend
(Died January 25, 2009)

Willam J. Barrett was born in Harrison, GA, and attended high school and college in Macon, GA. Meticulous and analytical, he was drawn to science and received his Masters degree in Chemistry from Mercer University at the age of 22. He did further graduate work at New York University and obtained a Ph.D. from the University of Florida which he attended with his wife, Marvilyn Tippett, to whom he was happily married for 40 years. He worked for the Navy during World War II and received a Distinguished Civilian Award for his work on submarines. During the Cold War, he moved to Birmingham, AL to work at Southern Research Institute. Chemical weapons developed during World War II were a threat to military and civilians populations; he led a group that was instrumental in developing methods to sense, inactivate, and destroy these deadly weapons.

A consummate scientist, Dr. Barrett was revered for his thoroughness and precision, his high standards for himself and others, and his ability to work across disciplines. His collaborations ranged from drug design and testing, through investigation of the Apollo 1 fire at Cape Canaveral, to analysis of particulate matter, carbon dioxide, and sulfur dioxide releases from coal-fired power plants. As Director of Research in Applied Science at SRI, Bill developed a team that was highly successful in producing technically excellent science. In an era when women were uncommon in science, he hired, trained, and promoted female scientists. A man of quiet dignity and uncommon skill, he was respected by colleagues, subordinates, superiors, and family.

A member of the Alabama Academy of Science for 53 years, Dr. Barrett served as President, Executive Director, and Trustee. He was awarded the Wright Gardner Award from the Academy in 2004 for his lifetime accomplishments in the field of science.

In addition to his wide-ranging interests in science, Dr. Barrett enjoyed geology, traveling, photography, and fishing. He was a devoted husband and wonderful father. It is a tribute to his character that he maintained a group of friends that ate lunch together every week for over forty years.

Dr. Barrett was preceded in death by his first wife, Marvilyn Tippett, the mother of his children; his second wife, Cora S. Barrett; his sister, Margaret Mathis; and his half-sister, Joanne Harvey.

He is survived by his four children, Jo Lyn Stricklin, Bill Barrett, Lina Barrett, and John Barrett; six grandchildren, Amanda Stricklin, Hardy Barrett, Hannah Barrett, Nathan Barrett, Laura Barrett, and Aaron Barrett; and a brother, Harry Barrett.

In honor of his love of science and his long relationship to the Alabama Academy of Science, the family requests that memorial donation be made to the Alabama Academy of Science.

AGENDA
ALABAMA ACADEMY OF SCIENCE
FALL 2008 EXECUTIVE COMMITTEE MEETING
SAMFORD UNIVERSITY
Saturday, October 18, 2008, 8:00 AM, Sciencenter 033

Call To order 8:05 AM
Attendance: Safaa Al-Hamdani, B.J. Bateman, Scott Brande, Brian Burnes, Daniel Kim, Ken Marion, Mark Meade, Mike Moeller, Taba Hamissou, Larry Krannich, Jane Nall, Mickie Powell, James Rayburn, Ken Roblee, D. Brian Thompson, Brian Toone,

Review of Minutes from spring 2008 meeting

Action Items from Fall 2008 Executive Committee Meeting

	Action Item	*Action Taken*	*Person Responsible*	*Due Date*
B2	Identify individuals to fill vacancies on committees and for officer positions.	Done	Ken Roblee & Nominating Committee	Dec. 2008 Feb 2009
B7	Obtain one page biographies for Alabama university scientists for inclusion in each issue of the journal.	Done		Each JAAS issue
B7	Identify other organizations as potential advertisers in the journal Honda, Dupont, Texas instrument, Vote to accept $1000 for Centage to advertise in journal	 Passed	Exec. Committee	Dec. 2008
B12-IV	Locate a new chair for the Geography, Forestry, Conservation & Planning Section.		Ken Roblee	Dec. 2008

B12-XII	Request to commit funds from the AAS budget to assist in recruiting special speakers for Sections. Even a small amount that might pay for one night in a hotel room would help. -Hotel room for invited speakers - and free admission Motion for this year all section can submit 1 bio for a single person to to 1 free room for as an invited speaker to be reviewed and selected by the executive committee by Jan 15.	Passed.	Exec. Committee	Sept. 2008
C-2	Follow up on funds that AU Library sets aside for Journal support and utilize these funds.	Done	Treasurer	Each JAAS billing
C-2	Academy seriously needs to consider new revenue sources or reduce future budgeted expenses.	Done		Sept. 2008
C-13	Solicit nominees for the Gardner Award and Fellows of the Alabama Academy of Science	Underway	Prakash Sharma	Feb. 2009
C-14	Appoint new members to the Carmichael Award Committee	Suggested	Ken Roblee	Dec. 2009
C-17	Obtain nominations for the Mason Fellowship	Underway	Michael Moeller	Feb. 2009
C-18	Locate a high school science teacher to serve as a regional coordinator for each of the state regions.	Underway	Catherine Shields	
C-19	Activate a Paypal account	Done	Brian Toone	Fall 2008

Officers Reports (B)

1. **Board of Trustees**, Ken Marion -- No written report

2. **President**, Kenneth Roblee

My duties have involved:

- Working to set the 2009 annual meeting site at the University of West Alabama after Judson College withdraw their invitation in late Spring. The University of West Alabama selected Brian Burnes as the local arrangements coordinator.
- A site visit at UWA occurred on July 29 with Larry Krannich, Ellen Buckner, Brian Burnes, Brian Thompson, and myself in attendance. We toured the facilities available for the annual meeting, including classrooms for the section meetings, the cafeteria, and the new conference center where the banquet would occur.

- Ellen Buckner, Diane Tucker, Brian Thompson, and I interviewed the three candidates for the Gorgas-AJAS Teaching Fellow via WIMBA on August 5th Dr. Catherine Shields was offered the position and she accepted.

- Wrote letters confirming membership and participation in the AAS for individuals seeking tenure and promotion, filled out a survey for the NAAS, and worked with various Academy officers.

Brian Thompson and I contacted those officers and committee chairs whose terms expire to determine who would volunteer to eontinue in their positions. Most volunteered to continue and the positions remaining to be filled are: member on the Budget and Finance committee and member on the Senior Academy auditing committee.

Action Item: Fill vacant committee and officer positions as indicated in the table.

3. **President –Elect**, Brian Thompson

I have:

- Worked with Ken Roblee to fill vacant committee and officer positions.
- Attended the UWA site visit in late July and quite impressed with the facilities and planning under way for the upcoming spring annual meeting.
- Participated in the Gorgas-AJAS Teaching Fellow interviews this fall, arranged by Ellen Buckner.
- New updated materials were forwarded to update the Academy web-site.

4. **Second Vice President**, Brian Burnes-- No report submitted.

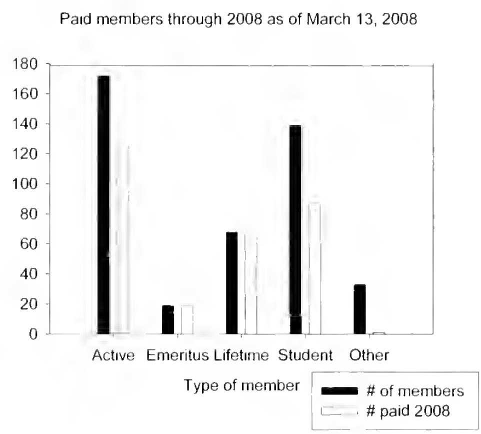
We discussed the planning committee report. A possible Symposium topic may focus of theBlack belt prairie region.

5. **Secretary,** Jim Rayburn

Since the Fall, I have

- Provided sets of labels of current members to Safaa Al-Hamdani for the Journal.
- Forwarded the minutes were to Dr. Al-Hamdani for printing in the Journal.
- Sent dues reminders and collected $5,880 in dues for 2008, $350 for 2009, and $55 for 2010.
- Maintained the membership roster. As of October 10, 2008 we have 322 members including library and 33 other members. This is a decrease of 36 members compared to this time last fall. The membership breakdown is 140 Active , 19 emeritus, 69 lifetime, and 61 student members (see figure below). The distribution by Section is as follows:

Section #	Total #	Not Paid
1	135	37
2	32	6
3	4	0
4	6	1
5	89	56
6	4	1
7	6	2
8	18	3
9	45	12
10	15	7
11	10	3
12	3	1
77 (other	32	31
Non selected	32	3



Motion by Secretary: AAS will reimburse the JSU Biology Department for postage and paper cost associated with the secretary duties. Motion passed.

6. Treasurer, Taba Hamissou

The treasurer's report consists of the following:
All account balance as of October 11, 2008
Income and Expenses statement as of October 11, 2008

Since the March Annual Meeting, income to the the Academy was $19,826.05, while expenses were $30,394.72. Once interest income is taken into account, the assets have decreased by $9,008.98. The following tables summarize the financial activities of the Academy from March 14 to October 11, 2008.

Treasurer's Report
All Account Balances as of 10/11/2008

Account	Balance
ASSETS	
Bank accounts	
cd(1) + cd(2)	$20,891.50
Saving account	$1,261.91
Checking	$3,464.87
TOTAL ASSETS	$25,618.28

Financial Report
Alabama Academy of Science

March 14, 2008 – October 11, 2008

March, 2008 Executive Meeting	
cd(1) + cd(2) +cd(3)	$28,994.40
Saving account	$1,261.01
Money Market	$245.35
Checking account	$4,126.50
2007 Meeting overage	$2,100.00
Total Assets all accounts (March, 2008)	**$34,627.26**
October 10, 2008	
cd(1) + cd(2)	$20,891.50
Saving account	$1,261.91
Money Market	(closed)
Checking Account Balance	3,464.87
Total Academy Assets all accounts (October, 10, 2008)	**$25,618.28**
Total decline in assets this quarter	**$9,008.98**

March 14, 2008 – October 11, 2008

Income and Expenses Statement

Category Description	03/14/2008 – 10/11/2008
INFLOWS	
2007 annual meeting income	2,100.00
Dues received	745.00
JAAS Incomes	
Royalty	74.80
Authors contributions	300.00
ISEF inflow	16,606.25
TOTAL INFLOWS	**19,826.05**

OUTFLOWS

Annual Meeting	
Program booklets/momentis.	1,974.50
Students (travel, symposia, competition)	1,630.00
Mason Scholarship	1,000.00
Carmichael Award	250.00
Research grant	250.00
Honoraria	
Exec. Director	3,000.00
JAAS Editor	1,200.00
JAAS Secretary	800.00
JAAS Printing	3,102.60
JAAS mailing	499.15
Bank Charges	70.00
ISEF reimbursement	16,618.47
TOTAL OUTFLOWS	**30,394.72**

There was a discussion about the financial situation and that the funds available at the Auburn library have not been utilized for the printing of the Journal. Dues reminders should be e-mailed to all the Academy officers. The Executive Committee will revisit the financial outlook of the Academy at the Spring Executive Meeting.

7. Journal Editor, Safaa Al-Hamdani

The following has been accomplished since the last meeting:

- The Alabama Academy of Science Journal Vol. 79. No 2 has been successfully released.
- We are on time in releasing the October issue of the journal for 2008.
- Members of the Academy are urged to become more active in submitting papers to and volunteering to review manuscripts for the Journal.
- Each university in Alabama is encouraged to submit a one page biography of a selected scientist of their choice for publication in each issue of the journal.
- Tom Ash, the Executive Sales Representative for Cengage Learning - Brooks/Cole Pub.has informed me that they are willing to consider advertising in the journal.

Action Items:

1. Obtain one page biographies for Alabama university scientists for inclusion in each issue of the journal.
2. Identify other organizations as potential advertisers in the journal

8. Counselor to AJAS, B. J. Bateman

The 2008 Annual Meeting was shared jointly with the Alabama Academy of Science at Samford University withHugh Floyd serving as the local arrangements for the AJAS. Highlights of the program were:

- Paper Competition - The paper competition was conducted on Friday morning in the Sciencenter with the finals on Friday afternoon. Mason McFarland and Beth Clayton were chosen to represent Alabama in the national competition held at Orlando, Fl. The other three state winners (Christine McBride, Johanna Hendley, Shawn Tuteja) and Catherine Shields accompanied Mason and Beth to Orlando. Shawn was able to compete in the poster competition.
- Banquet - More than One hundred students, teachers, university professors, and members of business, industry and government shared the Thursday night banquet.
- Business Meeting - The customary AJAS business meeting was held on Friday afternoon. This provided a time for announcing the overall winner, the outstanding region, the outstanding teacher(s), and other awards.

Winners and Awards 2008

Honorable Mention	
Biological Sciences	Hannah Faulkner (Brooks HS)
Physical Science	Rebecca Holden (Brooks HS
"Best with the Least"	
Biological Sciences	Mason McFarland (JCIB)
Humanities	Kassie Abel (Deshler HS)
Mathematics	Johanna Hendley (JCIB)
Physical Science	Kate LeCroy (JCIB)
Second Place	
Biological Sciences	Lauren Nelson (JCIB)
Engineering	William B Kirkland (JCIB)
Humanities	Julie Borden (JCIB)
Mathematics	Charlotte Mae Crother Kent (JCIB)
Physical Science	Kate LeCroy (JCIB)
First Place	
Biological Sciences	Mason McFarland (JCIB)
Engineering	Christine McBride (JCIB)
Humanities	Beth Clayton (JCIB)
Mathematics	Johanna Hendley (JCIB)
Physical Science	Shawn Tuteja (Altamont HS)

Research Grant Awards

Carley Andrews	\$60.00
Rebecca Daniels	\$60.00
Hannah Faulkner.	\$60.00
Jessica Swinea.	\$60.00
Rebecca Holden	\$60.00
Jeanene Daniels.	\$60.00

AAAS Award	Jessica Swinea
Outstanding Teacher Award	Jeanene Daniels
Outstanding Region	Central
First overall	Mason McFarland
Second overall	Beth Clayton
Third overall	Shawn Tuteja

Newly elected officers for 2008-2009:

President	Jessica Swinea	Brooks High School
Vice-President	Kassie Able	Deshler High School
Treasurer	Mason McFarland	JCIB
Secretary	Shawn Tuteja	Altamont School

24 students, sponsors, and counselors attended the annual meeting as JSHS participants.

9. **Science Fair Coordinator**, Virginia Valardi

The 59th International Science and Engineering Fair was held in Atlanta, Georgia May 11th -16th 2008. Attending from across Alabama were 19 student finalists, 1 student observer and a host of parents/teachers from across Alabama. Over 1500 students from 51 countries around the globe attended this event, which is the world's largest pre-college science and engineering competition.

Alabama had four student projects that won awards at the international competition. One student, Nicholas Christensen won two awards. The following awards were received by Alabama students:

Fourth Award of \$500

Do You 'ear Wha' I 'ear? Redigitizing Voice Signals into Lower Frequencies to Revolutionize Hearing Assistance Technology, Nicholas Mycroft Christensen, 16, Wetumpka High School, Wetumpka, Alabama

Third Award of \$1,000

Carbon Fiber Makes a Pointe, Part Deux, Harper-Grace Niedermeyer, 17, Catholic High School, Huntsville, Alabama

Fourth Award of $500

The Kudzu Question: A Useful, Renewable Resource?, Kathryn Ann LeCroy, 17, Jefferson County International Baccalaureate School, Birmingham, Alabama

Special Awards:

Acoustical Society of America

Second Award of $500, in addition the student's school will be awarded $200, and the student's mentor will be awarded $100

Do You 'ear Wha' I 'ear? Redigitizing Voice Signals into Lower Frequencies to Revolutionize Hearing Assistance Technology, Nicholas Mycroft Christensen, 16, Wetumpka High School, Wetumpka, Alabama

Each winner will also receive a one-year ASA membership.

Patent and Trademark Office Society

The Special Awards given at the Intel ISEF encourage young inventors to develop new and useful products, and to pursue careers in science and technology.

Second Award of $200

Quest for Affordable Bio-Diesel: Characterizing Microbes for Conversion of the Bio-Diesel By-Product Glycerol, Sarah Elizabeth Stahl, 17, Huntsville High School, Huntsville, Alabama

The 2009 Intel International Science and Engineering Fair will be hosted by the City of Reno, NV and Gathering Genius, Inc. from May 10-16, 2009.

10. Science Olympiad Coordinator, Jane Nall

Herculean efforts are made each year by staff and volunteers on several university campuses, and teachers, parents, and students of over 200 public and private schools, so they might experience the joys and thrills of doing lab hands-on science.

Presently, registrations for teams and setting tournament hosts and dates are in progress. Probably due to the economy and funding cutbacks, fewer teams and hosting institutions are expected.

The elementary levels compete at various local and regional tournaments. Currently, the number of new teams registering has increased.

Science Olympiad events address the National Standards for Science Education and comprise all areas of science including astronomy, meteorology, experimental design, genetics, anatomy, process skills for life science and biology, chemistry and polymers, physics, earth science and fossils, and water quality and the environment, map skills, GIS and remote sensing as well as building events such as a Rube Goldberg-like device, robot, bottle rocket, plane, bridge and tower building, musical

instruments. Alternating events in taxonomy include topics of trees, amphibians and reptiles, birds, insects.

Still the best kept secret in the State, many volunteers of Alabama Science Olympiad continue to provide students the opportunity to participate and compete in Science Olympiad. Teachers, parents, coaches, bus drivers, university professors, university work study students, and other volunteers work to provide the students of Alabama the joys of "doing science" in an arena resembling athletic tournaments. More universities are needed to host tournaments! Consider showcasing your campus and join us in the fun! National this year will be at Augusta State University, Augusta, GA. The following is a listing of all the scheduled tournaments for this year.

ALABAMA SCIENCE OLYMPIAD 2008-2009
Division A2 Grades 3-6 Olympiad Tournaments

University of West Alabama, Grades 3-6, Tracy W. Duckworth, M.A.T. Lecturer of Biological Sciences. Univ. of West Alabama, Station 7, Livingston, AL 35470. ph (205)652-3732 fax 652-3831 twduckworth@uwa.edu

Jacksonville High School, Grades 3-6, David Peters, 1000 George Douthit Drive SW, Jacksonville, AL 36265 (256) 435-4177, www.esoatjhs.org

Auburn University, Grades 3-6, Greg Harris & Terry Tidwell, Department of Mathematics, 218 Parker Hall, Auburn, AL 36830 harriga@auburn.edu or tidweto@auburn.edu

Division B Grades 6-9 Olympiad Tournaments

Auburn University, Dr. Steve Stuckwisch, Department of Geology, 108 Tichenor Hall, Auburn University, AL 36830. (251) 844-6575 sstuckwisch@charter.net; http://www.auburn.edu/~stuckse/ScienceOlympiad/

University of Alabama at Huntsville, Mrs. Vanessa Colebaugh, 5019 Willow Creek Drive, Owens Cross Roads, AL 35763. (256) 922-5747 nessacita@comcast.net, http://www.uah.edu/sciolympiad/index.php

University of South Alabama, Dr. Cindy Stanfield, Dept. of Biomedical Science, UCOM 6000, Univ. of South Alabama, Mobile, AL 36608 (251) 380-2710 cthursto@usouthal.edu, http://www.southalabama.edu/alliedhealth/biomedical/SO/Index.htm

University of Alabama Dr. Kevin Whitaker, College of Engineering, P. O. Box 870200, The University of Alabama, Tuscaloosa, AL 35487-0200 (334) 348-1598. Contact Becky Snow, (334) 348-1598, bsnow@coe.eng.ua.edu

Division C Grades 9-12 Olympiad Tournaments

University of Alabama at Huntsville, Mrs. Vanessa Colebaugh, 5019 Willow Creek Drive, Owens Cross Roads, AL 35763. (256) 922-5747 nessacita@comcast.net, http://www.uah.edu/sciolympiad/index.php

University of South Alabama, Director to be determined, Univ. of South Alabama, Mobile, AL 36608

University of Alabama, Dr. Kevin Whitaker, College of Engineering, P. O. Box 870200, The University of Alabama, Tuscaloosa, AL 35487-0200 (334) 348-1598. Contact Becky Snow, (334) 348-1598, bsnow@coe.eng.ua.edu

State Science Olympiad Tournaments

Huntingdon College, Division B, Dr. Sidney Stubbs, Assoc. Vice President for Institutional Assessment and Compliance and Professor of Mathematics sstubbs@huntingdon.edu and Dr. Jim Daniels, Assoc. Prof. of Biology, jdaniels@huntingdon.edu , 1500 E Fairview Ave, Montgomery, AL 36106 (334) 833-4430

Jacksonville State University, Division C. Dr. Robert Carter, Associate Professor, Jacksonville State University, 700 N Pelham Rd, Jacksonville, AL 36265. 256-782-5144 rcarter@jsu.edu

National Science Olympiad

Augusta State University, William R. Wellnitz, Ph.D., Professor. Director, GA. Science Olympiad. Augusta State University, 2500 Walton Way Augusta GA 30904, 706.731.7993 (voice); 706.667.4098 (fax), wwellnit@aug.edu www.aug.edu/~bwellnitz or www.aug.edu/gaso

State Director: Jane Nall, 31110 Wakefield Drive, Spanish Fort, AL 36527 (251) 621-2911, email drnall@hotmail.com Alabama Science Olympiad web page: http://aso.jsu.edu/

11. Counselor to AAAS, Steve Watts

On December 10, 2008 the world will commemorate the 60th anniversary of the Universal Declaration of Human Rights. This document is the bedrock of the historic struggles to ensure governments fulfill their universally recognized human rights obligations. Towards that end, in 2007, the AAAS Science and Human Rights Program initiated a collaborative process to build a Science and Human Rights Coalition – a network of scientific associations, professional societies, and science academies that recognize that science and scientists are vital to the realization of human rights.

We are invited to take part in the launching of the AAAS Science and Human Rights Colalition on Janurary 14-16, 2009 in Washington, DC. Information can be obtained at http://shr.aaas.org.

We welcome the opportunity for any AAS member to attend the AAAS meeting on our behalf. Information about the AAAS can be obtained at www.aaasmeeting.org.

12. Section Officers

I. Biological Sciences, Mickie Powell

The final numbers for the 2008 meeting at Samford were:

A total of 72 presentations (41 papers and 31 posters) 24 students were entered in the competition for best paper and 13 students were entered in the competition for the best poster

At last year's meeting we agreed to include a separate competition for undergraduate presentations and posters, in the biological sciences section, to increase participation from schools that may not have graduate programs. The addition of a second place award for graduate students was also discussed and approved by the majority of members present.

Although Dr. Gene Hines (UAB, IACUC) expressed an interest in organizing a symposia on animal use and care in research for the 2009 meeting, due to scheduling conflicts such a symposium cannot be organized for that meeting. I will invite Dr. Hines to send a representative of his department to give a presentation on animal care and use in the general biological sciences section.

Dr. Megan Gibbons, Birmingham Southern College, is vice-chair for the Biological Sciences section.

A motion was made and approved that Mickie Powell will present a plan for making more than one student competition award for biology that includes when and how to implement the plan. This will be distributed to the Executive Committee by e-mail on January 15, 2009.

II. Chemistry, Daniel Kim

There were twenty-six participants in Section II-Chemistry during Spring 2008 AAS Meeting, which included the 4th annual Undergraduate Research Symposium jointly sponsored by the ACS Local Sections in Alabama. The section elected a new vice-chair (Emanuel A. Waddell from the University of Alabama in Huntsville) replacing Daniel Kim, who is now chair. A contact list

of chemistry professionals within the State of Alabama is being prepared to make contacts for the 2009 AAS Meeting. Submission of paper/posters titles and participation in the 2009 AAS Annual Meeting at UWA will be encouraged via e-mail.

III. Geology & Earth Science, Mark Puckett - No report submitted

IV. Geography, Forestry, Conservation & Planning, Greg Gaston -

Dr. Richard Hudiburg combined this Section IV (Geography, Forestry, Conservation & Planning) with the Section VIII (Behavioral and Social Sciences) session for the 2008 Annual Meeting at Samford University. Apparently, the combined session went well, with a few papers being presented in each topical area.

A new section chair must be located, because Dr. Gaston has decided he must resign from this position.

Action Item:
Locate a new chair for the Geography, Forestry, Conservation & Planning Section

V. Physics & Mathematics, Akshaya Kumar
A total of thirty research papers were presented in the Physics and Mathematics Section at the 85th annual meeting (March 19-22, 2008) of the Alabama Academy of Science, Inc. This consisted of twenty two oral and eight poster presentations. An invited talk on "Optical Characterization And Device Fabrication Of Wide Band Gap Semiconductors" by Dr. Minseo Park from Auburn University was also delivered.

Four student papers for oral presentations and one poster presentation were entered in the student award competition. There was a tie for best oral presentation award. It was given to two students, Mary E. Williams from the University of North Alabama and R. Hawrami from Alabama A& M. University. The best poster presentation award was given to Zachary A. Whitfield from Tuskegee University.

In 2009, we will continue our efforts to increase the number of participants in the physics and mathematics section.

VI. Industry & Economics, Marsha Griffin - No report submitted

VII. Science Education, Karen Utz - No report submitted

VIII. Behavior & Social Sciences, Richard Hudiburg

The joint session of Section IV – Geography, Forestry, Conservation, and Planning and Section VIII – Behavioral and Social Sciences was successful with 7 papers and 8 posters presented.

A vice-chair for section VIII was selected: Saramma T. Mathew of Troy University.

The section chair and vice-chair will make an effort to contact academic departments at colleges and universities in Alabama in order to encourage participation in the 86th annual meeting.

IX. Health Sciences, Melinda Lawson - No report submitted

X. Engineering & Computer Science, Brian Toone

At our annual meeting we had 3 poster presentations and 5 oral presentations. After the oral presentations, we had a short business meeting during which David Thorton (Auburn/JSU) was approached to determine if he would be interested in becoming the section vice-chair. This will be voted on at our next annual meeting.

XI. Anthropology, Harry Holstein -- No report submitted

XII. Bioethics & History/Philosophy of Science Michelle Sidler

The Spring 2008 Annual Meeting of Section XII saw an increase in the number of presentations from the previous year. We had five presentations, including a guest speaker, Lynn Holt, a Genetic Counselor from UAB, who discussed the ethics of genetic testing. We had a large audience and gathered a lot of interest in our Section. To increase participation for 2009, I am soliciting proposals from previous presenters and contacting departments and colleges around Alabama who may have interested faculty. In addition, I hope to have another guest speaker (to be determined), so I am looking forward to a bigger program as well as a larger audience.

Action Item:

Request a commitment of funds from the AAS budget to assist in recruiting special speakers for Sections. Even a small amount that might pay for one night in a hotel room would help.

13. **Executive Officer** Larry Krannich

Since March, 2008, I have been involved in the following activities:

- Distributed the Local Arrangements Manual to the local arrangements committee at the University of West Alabama to assist them concerning arrangements, program booklet needs, and deadlines associated with the annual meeting of the Academy to be held on the University of West Alabama campus, March 25-27, 2009.
- Attended the site visit at the University of West Alabama on July 29, 2008.
- Prepared letters for distribution in late October to Alabama colleges and universities to solicit financial support for the Journal.
- Prepared the Call for Papers for the 86th meeting of the Academy that will be distributed to all Section Chairs in hard and electronic copy after November 15th.
- Designed bookmarks advertising the Academy and participation in the annual meeting. These will be distributed statewide in late-November.
- Updated the fliers and letters being sent to all Alabama ehcmistry faculty to solicit the participation of undergraduates and Alabama college and university Chemistry faculty in the 5th annual Undergraduate Chemistry Research symposium to be held in conjunction with the annual meeting of the Academy.
- Contacted local sections of the Ameriean Chemical Society in the State to assess their willingness to again co-sponsor the state-wide undergraduate chemistry researeh symposium with the Academy.
- Consulted with Brian Toone, Editor for Electronic Media, to re-activate the on-line submission of Executive Committee reports and generate a compiled doeument for distribution to all attendees at the meeting.

Committee Reports (C)

1. **Local Arrangements**, Brian Burnes

The Local Arrangements Committee at the University of West Alabama has been involved in detailed planning for the 86th Annual AAS meeting to be held March 25-27, 2009. The following represents some of the initial plans we are presenting to the Executive Committee at the Fall Meeting. In addition, a mock-up of the registration webpage will be presented.

Budget

<u>Wednesday 03/25/09</u>	
Executive Council Dinner (Filet Mignon) 20 x $22.50=	$450.00
<u>Thursday 03/26/09</u>	
Morning (pastries and juice) 200 @ $3.75=	$750.00
Lunch (Cafeteria w/ID Badge)200 @ $5.70=	$1140.00
Afternoon (soda and snacks) 200 @ $4.25=	$850.00

Awards Banquet (Chicken Buffet)200 @ $9.75=	$1950.00
Friday 03/27/09	
Morning (pastries and juice) 150 @ $3.75=	$562.50
Lunch (Cafeteria w/ID Badge)150 @ $5.70=	$825.00
Afternoon (soda and snacks) 100 @ $4.25=	$425.00
Printing (Meeting programs) 400 @ $4.66=	$1864.00
(Banquet programs)200 @ $1.00=	$200.00
(badges) 400 @ $2.75=	$1100.00
Total	$10,116.50

Meeting Rooms

Room	Type	Seats	Computer/Projector
102	Lec	50	+
104	Lab	24	+
106	Lab	24	+
108D	Office	2	+
109	Lec	60	+
111	Lec	20	+
202	Lab	20	+
204	Lec	30	+
205	Conference	12	-
206	Lab	20	+
207	Lab	24	+
208	Lab	24	+
211	Lec	28	-
Bibb Graves Auditorium (3/27 only)		600	+
Bell Conference Center	300	+	

3. Class Schedule

Classes are in session and will meet in alternate locations.

4. Parking

Parking will be set aside in the Cafeteria and Lower Wallace Hall parking lots. Parking passes will not be issued, however, no parking violations will be ticketed by Campus Police on the meeting dates.

5. Lodging

1. McConnell House – 3 double bedrooms across from campus (FREE!)
2. President's House – 3 double bedrooms (2 rooms share one bath) in fine style on campus (FREE!)

3. Comfort Inn Livingston, 645 Hwy. 28 and I20, (205) 652-4839 -- 32 rooms reserved for "Alabama Academy of Science" at $76.49/night + tax, includes continental breakfast
4. Holiday Inn Express Demopolis, 943 Hwy. 80 West, 1 (888) 890-0245, rate TBA

6. Miscellaneous

Poster information: Posters are to be available for viewing in the lobby and east wing of Bibb Graves Building. Posters will be affixed to blank, numbered wall spaces using poster putty (supplied by the Poster Coordinator).

On-campus police, fire, medical: 205-652-3682
Off-campus police, emergency: 911

LOCAL ARRANGEMENTS COMMITTEE

The officers and members of the Academy express their appreciation to The University of West Alabama and the Local Arrangements Committee for their efforts in planning and hosting this 86th Annual Meeting.

Local Chair
Brian Burnes, Biology
bburnes@uwa.edu

University Liaison Officier
Richard Holland, President
rholland@uwa.edu

AAS Program Coordinator
Brian Burnes, Biology,
bburnes@uwa.edu

AJAS Program Coordinator
John McCall, Biology
jmccall@uwa.edu

Gorgas Program Coordinator
Jeffery Merida, Biology
jmerida@uwa.edu

Registration
Christi George, Information Systems
cjw@uwa.edu

Gorgas Scholarship Competition
Ellen Buckner, UAB School of Nursing
bucknere@uab.edu

Audiovisual/Computers
Information Systems Staff
cjw@uwa.edu

Parking & Traffic Coordinator
Lee Stanton, Biology
lstanton@uwa.edu

Poster Coordinators
Doug Wymer, Biology
dwymer@uwa.edu

Publicity/Web Master Coordinator
Christi George, Information Systems
cjw@uwa.edu

2. Finance, Ken Marion

The assets of the Academy as reported at the Fall Executive Committee meetings and Annual Spring meetings since 2001 are listed below.

	Assets	Change (End of Period)	Period	Assets (End of Period)	Change
1/1 – 10/12/2001	$71,763		1/1 – 12/31/2001	$75,813	
1/1 – 10/12/2002	$72,197	$434	1/1 – 12/31/2002	$72,813	$3,000
1/1 – 10/12/2003	$71,403	–$794	1/1 – 12/31/2003	$74,800	$1,987
1/1 – 10/26/2004	$74,265	$2,862	1/1 – 12/31/2004	$74,610*	–$190
1/1 – 10/26/2005	$63,895	–$10,370	1/1 – 12/31/2005	$65,561*	–$9,049
1/1 – 10/26/2006	$62,162	–$1,733	1/1 – 12/31/2006	$67,555*	$1,994
1/1 – 10/31/2007	$34,004	–$28,158	1/1 – 12/31/2007	$36,435*	–$31,120
1/1 – 10/10/2008	$25,618	–$8,386			

*estimated

The financial assets of the Academy continued to decline during 2008. The Treasurer's report indicates large expenses associated with the Journal of the AAS, and we also have annual outflows associated with the Science Fair. It is essential that we follow up on money the AU library receives from the state for support of the Journal. The Academy will seriously need to consider new revenue sources (i.e., increase in dues, increased meeting registration fees, etc.) or reduce future budgeted expenses.

Action Items:

1. Follow up on funds that AU Library sets aside for Journal support and utilize these funds.
2. Academy seriously needs to consider new revenue sources or reduce future budgeted expenses.

3. Membership, Mark Meade

I have no new business to report to the committee. Refer to B-5 (Secretary's report) for information on membership and dues.

4. Research, Steve Watts

This past year 26 students (up from 12 and 19 from 2007 and 2006, respectively) applied for travel awards to the 85th annual meeting. All were presenting papers or posters. All students were from out of town and were each awarded up to $35, depending on distance traveled. Budgeted amount for travel is $750. In addition, 6 students applied for research grants. The committee evaluated the grants and all of these were awarded in full ($1,000 of the budgeted amount of $2,400). Approximately 45 students (up from 12 last year and 23 the previous year) have applied for the Research Paper/Poster Competition in several sections. New (slightly modified) evaluation forms and suggested criteria were sent to all section chairs and are now on the web.

All categories of awards and activities were handled electronically for the fifth year. Several minor modifications may be needed for next year, but in general electronic submissions greatly improved the process.

As discussed last year, the paper/poster competition will be held on Thursday only, with the banquet on Thursday night where winners will be announced. This was difficult for some sections because of the large number of individual participating in the competition that did not allow for scheduling options.

5. **Long-Range Planning**, Adriane Ludwick

At the Spring Executive Meeting, the Committee was assigned two tasks.

- Evaluation of the Sections of the Academy towards the goal of recommending an update (no change; deletion of Section(s); combining of Section(s); renaming of Section(s), etc.)
- Consideration of named awards

The full Committee will be involved in discussions between the Fall and Spring. A full report will be given by the Committee at the Spring Executive Meeting.

6. **Auditing, Senior Academy,** Sergey Belyi -- No report submitted

7. **Auditing, Junior Academy,** Henry Barwood -- No report submitted

8. **Editorial Board & Associate Journal Editors,** Thane Wibbels -- No report submitted

9. **Place and Date of Meeting**, Mark Meade

The 2009 meeting is scheduled for the University of West Alabama. The 2010 meeting is scheduled for Alabama A&M and the 2011 meeting is scheduled for Jacksonville State University. We discussed the possibility of UAB in the future.

10. **Public Relations,** Roland Dute

Recently, I attempted to enlist the services of the associate editor of the College of Sciences and Mathematics at Auburn University to distribute our press releases. The editor agreed, but his acceptance was conditional to the dean's approval. The dean was not receptive to my request.

11. **Archives**, Troy Best

We need to obtain photographs (especially of members of the Executive Committee), committee reports, minutes of the AAS Executive Committee meetings, and any other materials that may be of interest to our membership. Items that may not seem of interest at present may be of great interest in the future. Photographs of officers and members at meetings are of special interest.

If you have items that you believe may be worthy of inclusion in the AAS Archives, please send them to me or to Dr. Dwayne D. Cox, University Archivist, Auburn University Ralph B. Draughon Library, 231 Mell Street, Auburn University, AL 36849.

Access to our AAS Archives is available 7:45-4:45 Monday-Friday. Dr. Cox has provided the following information relative to access. Archives materials **do not** go out on interlibrary loan. Patrons can come in and use them according to the donor specifications. Some require special permission from the donating office or persons who made the donation or sometimes the archivist. Materials to be used at night or weekends need to have special arrangements made so they can be pulled before 4:30 in the afternoon (Friday afternoon for weekend use). Copies can be made in most cases and that can be done either by going through InfoQuest or contacting Dr. Cox or the reference desk at 334/844-1732.

I encourage all officers and members of the AAS to donate significant documents, photographs, etc. to the archives.

12. **Science and Public Policy**, Scott Brande - No report submitted

13. **Gardner and Fellow Award**, Prakash Sharma
Each member of the Academy is requested to publicize to individuals, heads of departments, deans and provosts of colleges and universities about the Gardner award. The nomination should be forwarded to:

> Dr. P. C. Sharma, Chair, Wright Gardner & Fellow Award Committee,
> Head of Physics Department
> Tuskegee University
> Tuskegee, AL 36088.
> Phone: (334) 727-8998; Fax: (334) 724-3917
> e-mail: pcsharma@tuskegee.edu

You are welcome to nominate by either e-mail or mailing a hard copy.
The nominations should consist of the following documents.

> (i) Formal Nomination Letter, (ii) vitae and at least three letters of references from
> peers, administrators and one by an expert in area of his/her research, and (iii) one page citation that will be used for presentation of the award.

Anything missing from items (i, ii, iii) will result in rejection of the nomination. **The closing date for nominations is January 10, 2009.** The award will be presented in the "Joint Annual Meeting of Junior and Senior Alabama Academy of Science, 2009.

FELLOW OF ALABAMA ACADEMY OF SCIENCE (FAAS)

You are welcome to nominate by either e-mail or mailing a hard copy to the above address.

The nominations should consist of the following documents.

> (i) Formal Nomination Letter, (ii) vitae and at least four letters of references from experts in area of his/her research and (iii) one page citation that will be used for presentation of the award.

Anything missing from items (i, ii, iii) will result in rejection of the nomination. **The closing date for nominations is January 10, 2009.** The award will be presented in the "Joint Annual Meeting of Junior and Senior Alabama Academy of Science Meeting, 2009.

Action Items

1. Obtain nominations for the Gardner Award
2. Obtain nominations for FAAS
3. Add Gardner Award and FAAS nomination forms to the Academy web-site

14. Carmichael Award, Richard Hudiburg

This committee will review articles published in Volume 79 *The Journal of the Alabama Academy of Science.*

The committee needs new members to be appointed in order to participate in review process.

Action Item

Appoint new members to the Carmichael Award Committee (Steven Carey and David Nelson should be recommended to contacted to serve on committee.)

15. Resolutions, Mark Meade

The committee wrote two resolutions for last year's annual meeting at Samford University. One resolution was for the contributions of the late Ron Jenkins (Samford University and past-President of the Academy) and the other was for Samford's work towards the 2008 meeting. Anyone knowing of specific resolutions that need to be prepared for the 2009 Annual Meeting should contact me.

16. Nominating Committee, Brian Burnes No report submitted

17. Mason Scholarship, Mike Moeller

Last spring the Committee reviewed four completed applications for the William H. Mason Scholarship. After assessing all application materials the Scholarship Committee offered the $1000 scholarship to Mrs. Sherri Sanders Grosso. Mrs. Grosso accepted the award.

Action Item
Obtain applications for the 2009-2010 Mason Fellowship. Information and application materials are available on the Academy web-site.

DEADLINE FOR RECEIPT OF APPLICATIONS IS FEBRUARY 2, 2009

18. Gorgas Scholarship Program, Ellen Buckner

2008 Competition: We had an excellent competition at Samford University in 2008. The Final Press Release listing winners is attached. Thanks to all the teachers, students and judges who participated.

Gorgas-AJAS Teaching Fellow: At the Spring meeting the AAS Executive Committee approved the initiation of a Gorgas-AJAS Teaching Fellow. This new program, funded through the AJAS and Gorgas funds, is to develop the statewide network of science clubs affiliated with the AJAS and to encourage participation in the state science paper competition and Gorgas Scholarship program. Announcements were sent statewide and three outstanding candidates were interviewed. Several members of the Gorgas Committee and other AAS officers reviewed resumes and essays and gave feedback on the candidates. This is a new initiative for the Academy and it is hoped that a renewed enthusiasm for science among high school students will occur because of it

I am pleased to announce that Dr. Catherine Shields will serve as the 2008-2009 Gorgas-AJAS Teaching Fellow. Dr. Shields completed her PhD in Educational Psychology from the University of Alabama in 2007. She has been one of the most active teacher-mentor-sponsors of students entering the Gorgas competition and last spring received the Gorgas Outstanding Teacher Award. She also serves as the Central Region Counselor.

Dr. Shields began August 1 and her first report of activities is attached. She has established a website for the competitions and work closely with Dr. B.J. Bateman (AJAS State Counselor) and me to increase participation in these. She has many ideas for encouraging teacher involvement. .

The following are the rankings of the finalists of the 2008 Alabama Science Scholar Search. The Search was held at the meeting of the Alabama Academy of Science at Samford University, Birmingham, Alabama.

> The winner of the first-place tuition grant of $4000 was: Christopher Dean Romanczuk, 2907 Honors Row, Hampton Cove, AL 35763, Randolph School, 1005 Drake Avenue, Huntsville, AL 35802, Teacher-Sponsor, Peggy Walker

First alternate and winner of a tuition grant of $3000 was: Kathryn LeCroy, 1430 12th Plaza, Pleasant Grove, Alabama, 35127, Jefferson County International Baccalaureate, 6100 Old Leeds Road, Teacher-Sponsor, Debbie Anderson.

Second alternate and winner of a tuition grant of $2000 was: Daniel C. Wilson, 2716 Altadena Rd, Birmingham, Alabama, 35243, Shades Mountain Independent Church Academy, Birmingham, Alabama, 35226.

Third alternate and winner of a tuition grant of $1500 was: Ashley Elizabeth Getwan, 106 Dannon Drive, Gardendale, AL 35071, Jefferson County International Baccalaureate, 6100 Old Leeds Road, Birmingham, AL 35210, Teacher-Sponsor, Catherine Shields

Fourth alternates and winners of a tuition grant of $500 were: Ryan Edward Dawson, 940 Brandy Lane, Birmingham, AL, Jefferson County International Baccalaureate, 6100 Old Leeds Road, Birmingham, AL 35210, Teacher-Sponsor, Catherine Shields *and* Charlotte Mae Crowther Kent, 5244 Highland Trace Circle, Birmingham, AL 352125, Jefferson County International Baccalaureate, 6100 Old Leeds Road, Teacher-Sponsor Debbie Anderson

The Following were Unranked Finalists:

Phillip Higginbotham, 217 Guntersville Road, Arab, AL 35016, Jefferson County International Baccalaureate, 6100 Old Leeds Road, Birmingham, AL 35210, Teacher-Sponsor, Catherine Shields

Molly Kathleen Kirkpatrick, 951 County Road, 415, Killen, AL 35645, Brooks High School, 4300 Highway 72, Killen, AL 35645, Teacher-Sponsor, Vicki Farina

Aerial Murphy, 225 Bozeman Trail, Wetumpka, AL, Wetumpka High School, Wetumpka, AL 1251 Coosa River Parkway, Teacher-Sponsor, Virginia Vilardi

Melissa Renee Snow, P.O. Box 68, Butler, AL 36904, Patrician Academy, 901 South Mulberry Avenue, Butler, AL 36904, Teacher-Sponsor, Brett Evans

Kirstin Sockwell, 5896 Willow Ridge Road, Pinson, AL 35126, Jefferson County International Baccalaureate, 6100 Old Leeds Road, Birmingham, Al 35210, Teacher-Sponsor, Debbie Anderson

Whitney Kiara Thomas, 1204 Stonecrest Drive, Birmingham, AL 35235, Ramsey High School, 1800 13th Avenue South, Birmingham, AL 35205, Teacher-Sponsor, Dasi Mosley.

Information on the annual competition and awards may be found on the website at www.GorgasScholar.org. For further information, contact Dr. Ellen Buckner, Chairman, Gorgas Scholarship Competition, bucknere@uab.edu, or (205) 934-6799.

Catherine Shields, AJAS-Gorgas Fellow, submitted the following AJAS/Gorgas Fellow Activities:

Goals for September included initiation of a website for the Alabama Junior Academy of Science (AJAS) and advertising AJAS and Gorgas at the Alabama Science Teachers' Association (ASTA) meeting September 30 and October 1, 2008 in Birmingham. Thanks to the efforts of Brian Toone, the website was launched and linked to the Alabama Academy of Science and Gorgas websites. Visit the site at www.alabamaacademyofscience.org/ajas

At ASTA, there will be a session each day and a booth where teachers can find information. I will be sharing a session both days with Jarrod Lockhart, who coordinates the Central Region Science Fair competition. The same teachers and students will likely be interested in Science Fair, AJAS, and Gorgas. The hope is that having information about all three competitions shared in one session will increase traffic and enhance exposure. A booth has been reserved and members of the Academy have been asked to host the booth throughout the two days of the meeting. Fliers sharing information about AJAS and Gorgas will be distributed at the booth. These same fliers, along with a letter inviting teachers to the session and the booth, were mailed Wednesday, September 17, 2008 to chairs of the science departments at 451 public and private schools throughout the state.

Goals for ASTA include gathering names and contact information for interested teachers. Specifically, the goal is to locate a high school science teacher who is willing to serve as the regional coordinator for each of the state regions. Location of an interested teacher is the key to enticing students to participate in AJAS and Gorgas.

Action Item

Locate a high school science teacher to serve as a regional coordinator for each of the state regions.

19. Electronic Media, Brian Toone

Website:

I have made a number of routine updates to the website (announcements, etc…) as well as those listed below.

Annual Meeting Title and Abstract Submission:

Following the annual meeting, I updated the page for retrieving journal abstracts.

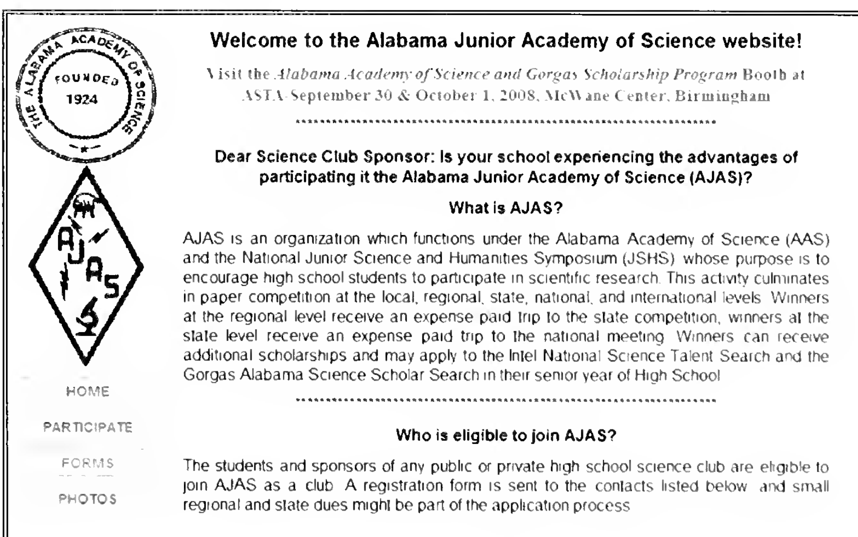
Fall Executive Report Submission Page

I updated the report submission page to gather reports for this Fall executive meeting.

Alabama Junior Academy of Science website

I created a website for the Alabama Junior Academy of Science based on materials and communication with Catherine Shields. The URL for the new website is: http://www.alabamaacademyofscience.org/ajas/

Screenshot included below:



Online Membership Application

I am still researching the costs and implementation procedure for paying membership dues and renewals online via Paypal membership and membership renewal. As a reminder - there is no monthly cost associated with this service, but each transaction is charged 2.9% + $0.30. For example, if we charge $30 for a one year membership, then $28.83 will be transferred to our Paypal account.

Action Item
Activate a Paypal account.

D. Old Business

1. Update on the Spring 2007 Action Item list.

Action Item	Action/ taken	Person Responsible	Due date
Look into setting up a science fair independent account for set up see science fair report	Passed		Fall 08
Solicit a one page biography for a scientist from each college/university in Alabama for inclusion in the journal.	Passed		
Recommend including advertisement in the journal. If approved, determine the mechanism for soliciting advertisements	Passed		May 08
Determine the most equitable mechanism for advancing funds to support travel to ISEF without depleting academy resources or adversely affecting the finances of the coordinator	Passed	Virginia Valardi, David Nelson, Vanessa Colebaugh, Barry Mask	Fall 08
Make a decision concerning a possible 2009 symposium on animal use and care in research.	Passed	Mickie Powell Brian Burnes	Fall 08
Establish a committee to evaluate section effectiveness and the possibility of revising the various section designations		Adrian Ludwick	Fall 08
Establish a committee to explore how to rejuvenate AJAS and the regional competitions	Deferred to C18 (Long Range Planning)		
Obtain pictures of the Executive Committee and Annual meeting and submit these to the archives.	Agreed		End of meeting
Obtain nominations for the Gardner Award for next year.	Agreed		Feb 09
Develop an on-line submittal form for Gardner Award nominations	Agreed	Brian Toone	Fall 08
Approve these two resolutions and read both resolutions at the Joint AJAS/AAS Banquet on Thursday even, March 20, 2008	Passed as amended		
Proposed initiative to re-establish the network for science competition.	No action recorded		
Use on-line payment of membership dues using PayPal.	approved	Brian Toone	Fall 08
Constitution and By-Law change to W.H. Mason scholarship committee	Approved	Full business meeting	

E. New Business

A motion was made and passed to drop the invocation from the Banquet.

F. Adjournment ~12:00 pm

Members of Alabama Academy of Sciences (2009)

Uchenna N. Akpom
Safaa Al-Hamdani
Muhammad Ali
Robert A. Angus
Arthur G. Appel
David Arrington
Rebecca Baggott
Mark and Karan Bailey
Laszlo Baksay
Wayne T. Barger
David Barnhill
John A. Barone
William J Barrett
Robert P Bauman
Janis Beaird
Janis Beaird
Jordan Beard
TE Bearden
John M Beaton
Lee R Beck
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Ronald Benjamin
Troy L. Best
Kamala N. Bhat
Thomas Bilbo
Neil Billington
Benjie Blair
Lisa Ann Blankinship
Jacob Bodyston
John Boncek
Haley Booker
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Sonja Brooks
David C Brown
Lisa Buchanan
LW Buckalew
Ellen Buckner
Charles E Bugg
Shuntele N. Burns
Laura Busenlehner
Gayle Bush
Houston Byrd
Erick Caamano
Steven Carey
Jan Case
Ashley Kay Casey
Carolyn Cassady
Gail H Cassell
Johnathan Catrett
Tanushree Chakravarty
Suman Chitrakar
Nancy Clark
Ben A Clements
George Cline
Mamie Thomas Coats
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College of Nursing
Loretta A. Cormier
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Anne Cusic
J William Dapper
Larry Davenport
Cheryl G. Davis
WR Davis
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Rosemary D Dusi
Roland R Dute
Hussain Elalaoui-Talibi
Geraldine M Emerson

Oskar M Essenwanger
Jenny Estes
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Michael Froning
Teshome Gabre
Edward B. Garner
Daphne Garner
Janet Gaton
Taneet Ghuman
Pranita Ghuman
Megan Gibbons
Victoria K. Gibbs
Linda Gibson
Zachary Giffith
Fred Gilbert, MD
Leslie R. Goertzen
Christopher Goodwin
Megan green
Marsha D Griffin
Jan Gryko
Robert T Gudauskas
Pryce "Pete" Haddix
James H Haggard
James H Haggard
Rosine W Hall
Mijitaba Hamissou
Sig Harden
Joseph G. Harrison
Leven S Hazlegrove
Paul Andrew Helminger
B Bart Henson
Jonathan Herbert
Donald Herbert
Miriam Helen Hill
Damian Hillman
Damon Hillman
Thandiwe Hlatywayo
Kimberly Hobbs
A Priscilla Holland
Richard D Holland
Dan C. Holliman
Charles Holloway
Harry O Holstein
Xing Hu
Richard A Hudiburg
Jason Hudson
Ronald N. Hunsinger
Brenda W Iddins
Thomas Jackson
Thomas S Jandebeur
Jacqueline Johnson
Adriel D Johnson
Ivy Krystal Jones
Sharyn Jones
Melissa Jones
Blaire M. Jones
Dr. Wilson Judson College
Ellene Kebede
Robin Kelly
Constance Kersten
Constance A. Kersten
Chang-Hyun Kim
Christopher King
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Bradley R. Newcomer
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Chelsie Noland
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Hambolu Oluwaseyi

Eugene Omasta
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Minseo Park
Donald L Parker
Scott C Parrish
Robert Parrish
Christi Perkins
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Mikel D. Petty
Erin Phillips
Robert E Pieroni
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Marshall Pitts
Morgan S Ponder
Morgan S Ponder
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- The author(s) should provide the names and addresses of at least two potential reviewers.
- Assemble the manuscript in the following order: Title Page, Abstract Page, Text, Brief acknowledgments (if needed), Literature Cited, Figure Legends, Tables, Figures.

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The original and two copies of the manuscript and a cover letter should be submitted to the following.

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